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2011 Ground Robotics Capabilities Conference and Exhibition

"Saving Lives, Saving $ - Are Robot Recruits the Answer?"

Orlando, FL

22 – 24 March 2011

Agenda

Wednesday, March 23, 2011

OSD INTRODUCTION
- Mr. Jose Gonzalez, Deputy Director, OSD Land Warfare & Munitions

GOVERNMENT CHIEF ROBOTICIST PANEL
Moderator: Dr. Greg Hudas, Chief Technologist, RDECOM TARDEC Robotics
- Dr. Jim Overholt, Senior Research Scientist-Robotics, Tank and Automotive Research Center, U.S. Army
- Mr. Michael Bruch, Ground Vehicle Autonomy Lead, Office of Naval Research, USMC
- Dr. Jeffrey Wit, Senior Research Scientist, Air Force Research Laboratory, Robotics Research Group, USAF

GUEST SPEAKER
- Mr. Scott Davis, Program Executive Officer for Ground Combat Systems, U.S. Army

GUEST SPEAKER
- LTG Michael Vane, Army Capabilities Integrations Center

Thursday, March 24, 2011

JGRE UPDATE
- Mr. Rob Maline, Director, Joint Ground Robotics Enterprise, OSD

GUEST SPEAKER
- LtCol David Thompson, Project Manager, Robotic Systems Joint Program Office

GUEST SPEAKERS
- Mr. David Heaven, National Bomb Squad Commanders Advisory Board
- Mr. Tony Detrick, Technical Support Working Group

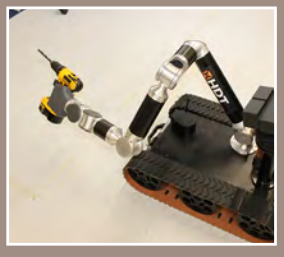
NDIA
National Defense Industrial Association

PROMOTING NATIONAL SECURITY SINCE 1919

2011 GROUND ROBOTICS CAPABILITIES CONFERENCE AND EXHIBITION

Supported by the Office of the Secretary of Defense, Joint Ground Robotics Enterprise

"Saving Lives, Saving $ – Are Robot Recruits the Answer?"



LOEWS ROYAL PACIFIC ► ORLANDO, FL

MARCH 22–24, 2011

WWW.NDIA.ORG/MEETINGS/1380

EVENT #1380

TUESDAY, MARCH 22, 2011

4:00 pm-6:30 pm REGISTRATION OPENS

5:00 pm-6:30 pm NETWORKING RECEPTION Sponsored by: QinetiQ North America

5:50 pm-6:20pm "Indoor demos of cutting-edge robotics technologies"- Exhibit Hall
QinetiQ, Black i Robotics & Recon Robotics

WEDNESDAY, MARCH 23, 2011

7:00 am-8:00 am REGISTRATION AND CONTINENTAL BREAKFAST Sponsored by: ManTech International Corporation

8:00 am WELCOME

8:05 am ADMINISTRATIVE COMMENTS
- VADM Joe Dyer, USN (Ret)
  COO, iRobot & Robotics Division Chair, NDIA

8:10 am OSD INTRODUCTION
- Mr. Jose Gonzalez, Deputy Director, OSD Land Warfare & Munitions

8:15 am-9:15 am KEYNOTE SPEAKER
- Gen James Cartwright, USMC, Vice Chairman, Joint Chiefs of Staff

9:15 am-10:15 am GOVERNMENT CHIEF ROBOTICIST PANEL

Moderator: Dr. Greg Hudas, Chief Technologist, RDECOM TARDEC Robotics

- Dr. Jim Overholt, Senior Research Scientist-Robotics, Tank and Automotive Research Center, U.S. Army
- Mr. Byron Brezina, Robotics Technologist Acquisition & Technology Department Naval EOD Technology Division, U.S. Navy
- Dr. Gill Pratt, Program Manager, Defense Sciences Office, DARPA
- Mr. Michael Bruch, Ground Vehicle Autonomy Lead, Office of Naval Research, USMC
- Dr. Jeffrey Wit, Senior Research Scientist, Air Force Research Laboratory, Robotics Research Group, USAF

10:15 am-10:30 am BREAK IN EXHIBIT HALL Sponsored by: NORTHROP GRUMMAN Remotec

10:30 am-11:00 am GUEST SPEAKER
- Mr. Scott Davis, Program Executive Officer for Ground Combat Systems, U.S. Army

10:30 am-11:00 am GUEST SPEAKER
- Mr. Jon Dudas, President of FIRST

11:30 am-12:30 pm FT. BLISS LESSONS LEARNED PANEL

Moderator: MG Robert Brown, Commanding General, The Maneuver Center of Excellence
- Col Daniel Pinnell, Commander, 2nd Brigade 1st Armored Division

12:30 pm-1:00 pm GUEST SPEAKER
- LTG Michael Vane, Army Capabilities Integrations Center

1:00 pm-2:30 pm LUNCH & AWARD PRESENTATIONS Sponsored by: BOEING

2:30 pm-5:00 pm Cirque des ROBOTS

"Indoor & Outdoor demos of cutting-edge robotics technologies"

ARA	Segway
Charles Rivier Analytics	SPAWAR
Harris	Square-1
iRobot	CMU/NREC
MacroUSA	Lockheed Martin
Robo-team	Palfinger
QinetiQ	TORC

WEDNESDAY, MARCH 23, 2011

3:40 pm-4:00 pm **BREAK IN EXHIBIT HALL & OUTDOOR DEMOS Sponsored by:** NORTHROP GRUMMAN / Remotec

5:00 pm-6:30 pm **GRAND RECEPTION Sponsored by:** iRobot®

6:00 pm-6:20 pm **"Indoor demos of cutting-edge robotics technologies"- Exhibit Hall**
iRobot & Remotec

THURSDAY, MARCH 24, 2011

7:00 am-8:00 am **REGISTRATION AND CONTINENTAL BREAKFAST Sponsored by:** ManTech International Corporation®

8:00 am **OPENING REMARKS**
- VADM Joe Dyer, USN (Ret)
  COO, iRobot & Robotics Division Chair, NDIA

8:10 am-8:40 am **GUEST SPEAKER**
- Capt Robert Allen, Tactical Operations, Palm Beach County Sheriff's Office

8:40 am-9:20 am **KEYNOTE SPEAKER**
- Mr. Frank Kendall, Principal Deputy Under Secretary of Defense for Acquisition, Technology and Logistics, OSD

9:20 am-9:40 am **JGRE UPDATE**
- Mr. Rob Maline, Director, Joint Ground Robotics Enterprise, OSD

9:40 am-10:00 am **BREAK IN EXHIBIT HALL**

10:00 am-10:30 am **GUEST SPEAKER**
- LtCol David Thompson, Project Manager, Robotic Systems Joint Program Office

10:30 am-11:15 am **GUEST SPEAKERS**
- Mr. David Heaven, National Bomb Squad Commanders Advisory Board
- Mr. Tony Detrick, Technical Support Working Group

11:15 am-12:45 pm **WARFIGHTER/USER PANEL**

Moderator: LtCol David Thompson, Project Manager, Robotic Systems Joint Program Office

- Maj Patrick Reynolds, LCE Branch Head, Technology Division Marine Corps Warfighting Laboratory
- Capt Robert Allen, Tactical Operations, Palm Beach County Sheriff's Office
- EODCS Sean Robertson, Chair, JSEOD Equipment Review Board
- Capt Thomas Eckel, USAF EOD
- SFC Neal Feldman, Combat Engineer

12:45 pm **WRAP UP**
- Mr. Rob Maline, Director, Joint Ground Robotics Enterprise, OSD

1:00 pm **CONFERENCE ADJOURNED**

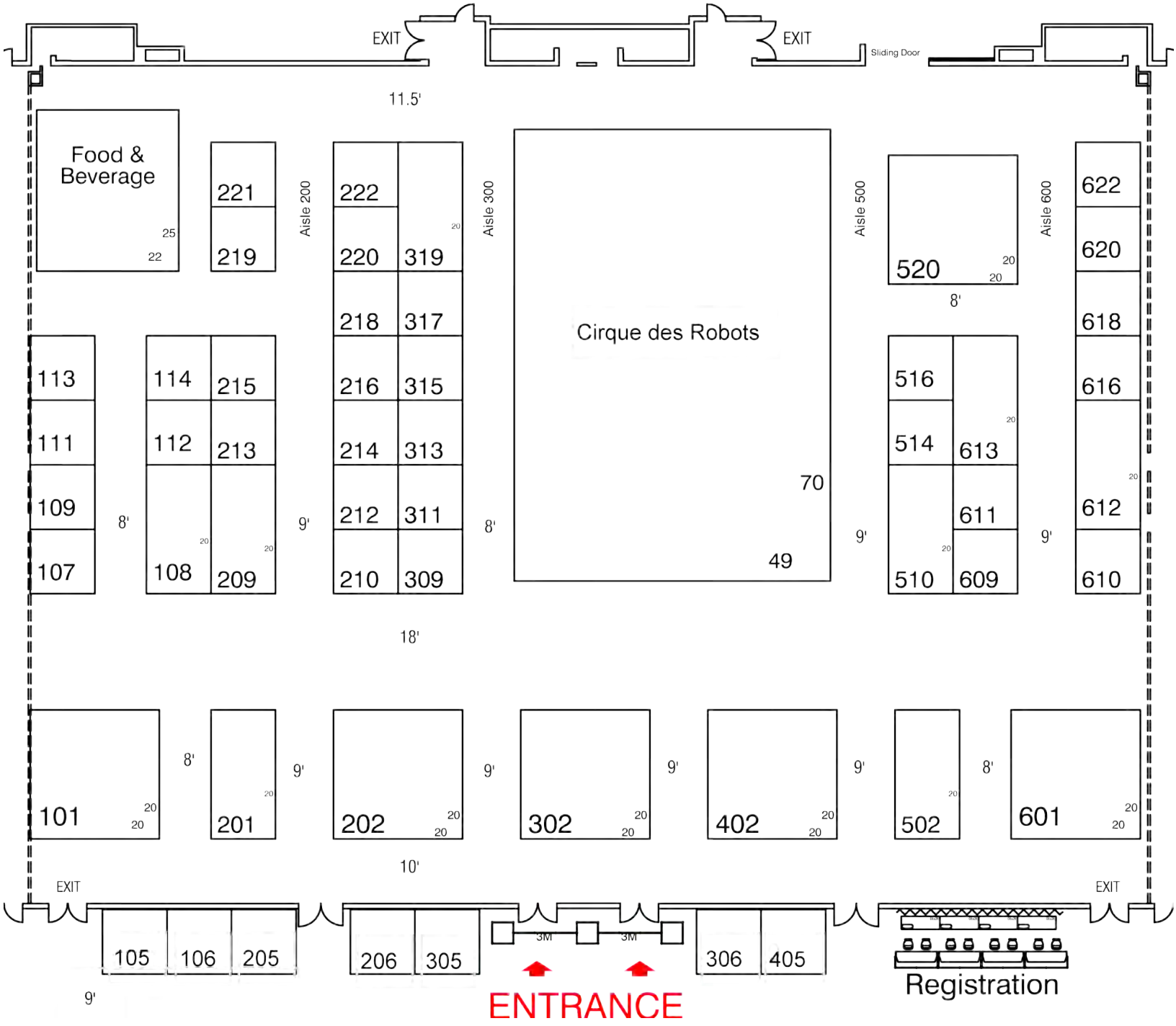
EXHIBITOR INFORMATION BY COMPANY:

EXHIBITOR INFORMATION BY BOOTH #:

Robotics Technology Consortium - RTC	101
AnthoTronix, Inc.	101
Charles River Analytics, Inc.	101
Chatten Associates, Inc.	101
Macro USA Corporation	101
Oceaneering Space Systems	101
Square One Systems Design, Inc.	101
SRI International – Sarnoff	101
Themis Computer	101
Virtus Advanced Sensors	101
Mesa Technologies	107
Lockheed Martin	108
Schafer	109
Quantum3D	111
American Reliance, Inc. (AMREL)	112
Silvus Technologies	113
SPAWAR	114
RE2, Inc.	201
ReconRobotics, Inc.	202
Patco Electronics; Division of TRC	205
Autonomoustuff	206
Cobham Tactical Communications & Surveillance	209
Air Force Research Laboratory	210
Oshkosh Defense	212
Autonomous Solutions	213
University of Michigan - GRRC	214
JAUS Tool Set	215
Tactical Defense Media Inc.	216
SRI International	218
Packaging Strategies	219
IMT	220
National Robotics Engineering Center	221
Robotic Research, LLC	222
iRobot Corporation	302
Kairos Autonomi	305
Applied Research Associates	306
Stratom, Inc.	309
Think-A-Move, Ltd.	311
Segway Robotics	313
National Robotics Training Center	315
Vecna Technologies	317
Black i Robotics	319
HDT Engineered Technologies	402
Northrop Grumman Remotec	502
TORC	510
MAS Zengrange Ltd.	514
Contineo Robotics	516
QinetiQ North America	520
DARPA	601
C4ISR Journal & Defense News	609
Broadcast Microwave Services	610
Morpho Detection - formerly GE Security	611
Navy EOD Technology Division	612
The Boeing Company	613
Roboteam	616
Harris Corporation	618
ARDEC	620
Simulator Systems International	622

EXHIBIT HALL FLOOR PLAN

2011 Ground Robotics Capabilities Conference & Exhibition
March 22-24, 2011
Loews Royal Pacific Resort at Universal Orlando
Orlando, Florida



EXHIBITOR PROFILES:

Air Force Research Laboratory- Booth # 210: The Robotics Research Group of the Air Force Research Laboratory concentrates its research on developing systems that augment and support the warfighter for dull, dirty, dangerous, and impossible mission tasks. Research efforts are focused on the application of robotic technologies in response to existing and emerging USAF and DoD needs.

American Reliance, Inc. (AMREL). - Booth # 112: AMREL uses their well-known ROCKY rugged, mobile, computing platforms to design and manufacture customized, interoperable solutions. Combat-proven AMREL computers are independently certified for MIL-STDs 810/461. By employing field-expedient swappable modules, AMREL's patent-pending Flexpedient® Solutions enable one OCU to control multiple unmanned systems. Common control is here and now. Visit www.commoncontrol.com.

Applied Research Associates - Booth # 306: Applied Research Associates (ARA) is an international research and engineering company with a broad range of expertise in defense technologies, civil engineering, computer software and simulation, systems analysis, environmental technologies, and blast testing and measurement. We also manufacture robotic vehicles and technical products for environmental site characterization and pavement evaluation.

ARDEC - Booth # 620: ARDEC is an internationally acknowledged hub for the advancement of armaments technology and engineering innovation. Our mission is to develop, maintain, execute and manage integrated life cycle engineering processes required for the research, development, production, field support and demilitarization of munitions, weapons, fire control and associated items.

Autonomous Solutions - Booth # 213: Autonomous Solutions has long been a leader in vehicle automation, payload development for EOD robots, and JAUS C2 software. While its main business continues to be vehicle automation for mining, agricultural, and military applications, the company also has programs in autonomous manipulation, long-range perception, and 3D world-building.

Autonomoustuff - Booth # 206: Autonomoustuff is a leader in specialized high tech product distribution focusing on supplying today's specialized products to help provide tomorrow's solutions. Our daily work is driven by the ambition to provide the best supplier resource providing technology products related to autonomous driving, terrain mapping, collision avoidance, object tracking, and intersection safety.

Black i Robotics - Booth # 319: Black-I Robotics designs and manufactures Affordable Robust Mid-Sized (ARMS) UGV's for Defense and Homeland Security applications. The platforms have capabilities to remotely perform above ground and subsurface reconnaissance, provide explosive hazard evaluation, and delivery of tools and sensors in hazardous work environments.

Broadcast Microwave Services - Booth # 610: BMS provides digital microwave Video Data links meeting the latest requirements of today's Unmanned Systems. Supplying HD, SD Video, and/or a high Data Rate, BMS's full line of Transmitters, Receivers, and Antennas afford system solutions with superior Link Range and optimized Occupied RF Bandwidth. The equipment, designed for small UAVs and UGVs, incorporates minimum size, weight and power performance.

Cobham Tactical Communications & Surveillance - Booth # 209: Cobham Tactical Communications & Surveillance is the market leader for UGV deployment applications. Our mission is to provide our customers the best set of communication solutions relating to audio and video in tactical environments.

Contineo Robotics - Booth # 516: Contineo Robotics was formed by leaders from the DARPA Revolutionizing Prosthetics Program and the Johns Hopkins Applied Physics Laboratory to provide dexterous manipulation capability to a variety of robotic applications. Contineo is currently developing a continuum of improved terminal devices that incorporate conformal grasping and variable compliance to enhance functionality and improve user safety.

DARPA - Booth # 601: DARPA's Autonomous Robotic Manipulation (ARM) program hopes to transform robotics by achieving autonomy and high adaptability. ARM aims to develop software and hardware that enables a robot to autonomously perform complex tasks given only high-level control. The Software Track intends to solve autonomous manipulation tasks. The Hardware Track seeks to develop robust, low-cost hands. The Outreach Track provides public access to the ARM robot, allowing anyone to run their code to complete tasks.

EXHIBITOR PROFILES CONT.:

C4ISR Journal & Defense News - Booth # 609: C4ISR Journal and Defense News are leading sources for C4ISR, cyberspace and defense information worldwide. C4ISR Journal is the authoritative voice for the intelligence, surveillance, reconnaissance and cyberspace industries that shape modern warfare. Defense News is a weekly news publication covering the most important issues facing the worldwide defense industry.

Harris Corporation - Booth # 618: Harris is an international communications and information technology company serving government and commercial markets in more than 150 countries. Headquartered in Melbourne, Florida, the company has approximately $5 billion of annual revenue and more than 16,000 employees — including nearly 7,000 engineers and scientists. Harris is dedicated to developing best-in-class assured communications® products, systems, and services. Additional information can be found at www.harris.com.

HDT Engineered Technologies - Booth # 402: HDT Engineered Technologies (HDT) designs, develops and manufactures fully integrated, deployable engineered and expeditionary solutions. HDT engineers pioneered the development of a revolutionary new robotic arm that has applications in the medical, military and homeland security fields. Unique design features of this technology provide highly dexterous manipulation with a robust high degree of freedom system and the highest payload to mass ratio available.

IMT - Booth # 220: IMT's Military, Aerospace and Government products group specializes in innovative digital microwave solutions for defense, security and law enforcement applications. IMT product portfolio includes portable and ultra compact transmitters and receivers, COFDM microwave links, digital portable, fixed and airborne systems and specialty antennas.

iRobot Corporation - Booth # 302: iRobot – Robots that make a difference. More than 3,500 iRobot tactical mobile robots have been delivered worldwide. As a partner in the U.S. Army's modernization program, iRobot developed the SUGV, a robot for dismounted mobile operations and infantry missions. SUGV's predecessor, the iRobot® PackBot®, has performed thousands of dangerous missions while keeping troops out of harm's way. The iRobot® Warrior®, a large-class multi-mission robot supports multiple and heavy payloads.

JAUS Tool Set - Booth # 215: The JAUS standard has been in development for over ten years, and has gained in capability and complexity, increasing the barrier to entry. JTS is a tool that can sharply reduce that entry cost. JTS takes standard XML files, and generates human-readable documentation as well as C++ source code. It provides a Graphical User Interface to allow a user to define JAUS-compliant interface and saves that data as XML files. JTS includes monitoring and debug tools.

Kairos Autonomi - Booth # 305: Kairos Autonomi® offers cost-effective, superior unmanned technology with the patent-pending Pronto4™ Agnostic Autonomy System — a robotics appliqué kit field-installable on existing ground vehicles in about 4 hours. Capable of tele-operation, semi-autonomous or fully autonomous operations, the Pronto4 system is the preferred UGV solution for T&E, training, range clearance, and tactical operations.

Lockheed Martin - Booth # 108: Headquartered in Bethesda, Maryland, Lockheed Martin employs about 140,000 people worldwide and is principally engaged in the research, design, development, manufacture, integration and sustainment of advanced technology systems, products and services.

MAS Zengrange Ltd. - Booth # 514: MAS Zengrange manufacture high end Remote Initiation systems. The equipment is UK MOD DOSG and WESERB approved. The equipment is ideally suitable for mounting on ROVs which have no onboard firing circuits. This option creates a versatile platform with a 'Bolt On' fully approved remote firing circuit available to the user community.

Mesa Technologies - Booth # 107: MTI has extensive experience in ground support equipment, weapon systems integration, manufacturing and assembly machines; as well as machine & assembly facilities for prototype and full production manufacturing.

Morpho Detection - formerly GE Security - Booth # 611: Morpho Detection systems are deployed in more than 120 countries--in airports, customs checkpoints, border crossings, prisons and a wide range of other facilities. They are designed to defer terrorist attacks and help enforce drug laws and are renowned for superb sensitivity and ease of use.

EXHIBITOR PROFILES CONT.:

National Robotics Engineering Center - Booth # 221: The National Robotics Engineering Center (NREC) serves as the technology transition arm for Carnegie Mellon's Robotics Institute. The NREC excels in rapid integration and field-testing of automated systems and many have transitioned to industry and the military. The new mini-Crusher unmanned platform is on display at NREC's booth.

National Robotics Training Center - Booth # 315: NRTC offers academic credit and non-credit online training programs for the MSSC CPT and NRTC CRPT certifications. We provide all the curriculum & training modules required to establish a qualified workforce for robotics manufacturing. Our Manufacturing Engineering Process Program will guide the transition of small scale product development to an enhanced manufacturing arena that will ensure larger scale production of the unmanned project.

Navy EOD Technology Division - Booth # 612: As the largest concentration of EOD subject matter expertise in the world, the technologies we provide prevent injury and death. We strive to be the recognized leader and provider of choice to all our customers, by urgently focusing on capabilities in ordnance disposal technology and tools to counter Improvised Explosive Devices (IEDs). We are focused on increasing efficiency and effectiveness by providing state-of-the-art EOD technology solutions to Joint EOD warfighters around the world.

Northrop Grumman Remotec - Booth # 502: For over 25 years Remotec has served the military, EOD, Hazmat, and First Responders as a leading provider of mobile robotic systems for application into a variety of undesirable, hazardous, and potentially life threatening environments. More information is available online at remotec.northropgrumman.com.

Oshkosh Defense - Booth # 212: Oshkosh Defense, a division of Oshkosh Corporation, leads the way in military trucks and armored wheeled vehicles. Since 1917, Oshkosh has continuously developed new products and technologies that make military jobs easier, safer and more efficient. Oshkosh Defense's comprehensive product lines are recognized for superior performance and reliability, particularly in off-road environments. For more information, please visit www.oshkoshdefense.com. About Oshkosh Defense Oshkosh Defense, a division of Oshkosh Corporation, is an industry-leading global designer and manufacturer of tactical military trucks and armored wheeled vehicles, delivering a full product line of conventional and hybrid vehicles, advanced armor options, proprietary suspensions and vehicles with payloads that can exceed 70 tons. Oshkosh Defense provides a global service and supply network including full life-cycle support and remanufacturing, and its vehicles are recognized the world over for superior performance, reliability and protection. For more information, visit www.oshkoshdefense.com. The SandCat™ multi-functional vehicle from Oshkosh Defense enables special forces to respond to highrisk emergency situations with extreme confidence. This high-speed, well-protected, ultra-maneuverable vehicle can be specifically designed for a variety of tactical functions – from riot and crowd control to forced entry and insertion of tactical response units.

Packaging Strategies - Booth # 219: Packaging Strategies provides government and private sector customers with customers with custom transit and shipping cases and containers. Our skill set includes fulfillment of products as well as electronic system integration and manufacturing. Over twenty years of experience, PSI is a HUB ZONE small business certified and registered ISO 9001.

Patco Electronics; Division of TRC - Booth # 205: PATCO Electronics is a global provider of standard and engineered product power solutions for diverse applications. The company designs, develops, manufactures and markets a wide range rechargeable batteries, charging systems, battery management software and accessories for use in government, military applications and with prime OEM's equipment servicing these customer markets.

QinetiQ North America - Booth # 520: QinetiQ North America delivers world-class technology and responsive solutions to government agencies and commercial customers for many of their most urgent and complex challenges. More than 6,400 engineers, scientists and other professionals have the mission knowledge required to meet the demands of national defense, homeland security and information assurance customers.

Quantum3D - Booth # 111

EXHIBITOR PROFILES CONT.:

RE2, Inc. - Booth # 201: RE2, Inc. is a go-to provider of advanced robotic arms, innovative end-effectors, and automatic tool changing systems. RE2 offers three classes of power-dense manipulators ranging from small, lightweight arms to large, workhorse arms. RE2's field-proven Quick ReleaseTM technology is available for all classes of manipulators, providing reliable tool changing capability.

ReconRobotics, Inc. - Booth # 202: ReconRobotics, Inc. designs, manufactures and supports micro ground reconnaissance robots that are used by police tactical teams, the U.S. military and federal security agencies. These robots – the Recon Scout® Throwbot, Recon Scout IR and Recon Scout XT – are the only mobile, throwable robots in the world weighing less than 1.3 lbs.

Roboteam- Booth # 616: Roboteam is a dynamic company which leads in providing advanced robotic solutions covering: Designated robotic solutions, Advanced add-on's & sensors, Innovative concepts for man-robot interactions, Autonomous robotic missions and Simple & unique designs. The company develops quality, integrative and customized products, as a response to growing market needs, particularly in defense, healthcare and commercial applications.

Robotic Research, LLC - Booth # 222: Robotic Research, LLC provides autonomous technology expertise for unmanned systems, including: intelligent control, sensor processing, navigation, positioning, route planning, software development, and specialized applications. In addition to robotic capabilities, RR has created a human-worn or canine-carried localization and mapping system (Urban Mapping And Positioning System - UMAPS) for tracking the movements of the users in GPS-denied areas while simultaneously creating 2D/3D maps.

Robotics Technology Consortium - RTC - Booth # 101: The RTC is a non-profit that supports the efforts of the DoD and other Government organizations in regards to ground robotics tech. It was formed in '08 at the request of the JGRE, within the Office of the Secretary of Defense, and consists of large and small for-profit companies, academic institutions, and non-profit organizations. A specific purpose of the RTC is to engage companies and organizations that have not performed much if any work for the DoD and other Government organizations.

Schafer - Booth # 109: Connectivity - Interoperability – Affordability. Schafer's WiCM Mesh Network Communication Equipment and SCALE Situational Awareness Software provides simultaneous transmission and relay of video, voice, GPS, and data. Our compact and low power Mesh Network Nodes are integrated into UGVs, UGSs, UAVs, and OCUs. We simultaneously provide wireless command and control of multiple robots from one OCU while our displays enhance situational awareness to support Force Protection and ISR missions.

Segway Robotics - Booth # 313: The Segway Robotic Mobility Platform (RMP) takes the performance and engineering of the Segway Personal Transporter (PT) and makes it available in a customizable package for robotics applications. The RMP product line uses the same components that enabled a PT rider to travel more than 4,000 miles across the United States. These components were designed and tested to be highly reliable and durable, making the RMP ideal for moving heavy payloads in tight spaces over a variety of terrain.

Silvus Technologies - Booth # 113: Silvus Technologies is a leader in multi-antenna MIMO (multi-input, multi-output) wireless communications for robotic teleoperations and other bandwidth hungry military systems operating under harsh signal propagation environments. Silvus has developed the SC3000, a 4x4 MIMO, stand-alone, IP based packet radio transceiver for dual purpose use with advanced capabilities such as: networking, low latency video integration and wireless interference mitigation via spatial cancellation.

Simulator Systems International - Booth # 622: Simulator Systems (SSI) offers a full suite of easy- to - use, rugged, powerful and fast-deployable remote controlled robots ideally suited for EOD/IED neutralization, support and reconnaissance, urban warfare, first responder, surveillance/ hostage situations and other critical missions. All have hard anodized bodies, rechargeable Li-Fe batteries, and remote controllable color cameras with automatic IR.

SPAWAR - Booth # 114: The Space and Naval Warfare Systems Center Pacific (SSC Pacific) and its predecessor organizations (SSC San Diego, NRaD, NOSC, NUC, etc.) have been involved in various aspects of robotics since the early 1960's.

EXHIBITOR PROFILES CONT.:

SRI International - Booth # 218: SRI Sarnoff robotics technologies provide multi-modal perception and situational understanding. Our industry-leading solutions offer GPS-denied robot navigation, 3D mapping, pedestrian detection and multi-sensor fusion—delivering complete, small form factor robotic system solutions.

Stratom, Inc. - Booth # 309: Stratom provides R&D, engineering, and system integration services for unmanned systems applications. We have experience in the development and operations of commercially produced products and have developed robotic tools/tool kits for IED/ UXO threat detection and neutralization and combat engineering applications, as well as advanced technology in robotic logistics and refueling. Stratom has delivered solutions to multiple government / DoD entities as well as prime contractors.

Tactical Defense Media Inc. - Booth # 216: ARMOR & MOBILITYA Tactical Defense Media bi-monthly magazine dedicated to providing the latest news and information on current and future armor technologies and tactical missions. The publication offers readers provocative articles and insightful commentary on the state of DoD policy regarding key programs, acquisition and sustainment initiatives and looks at how decisions by Congress and the Pentagon directly influence actions on the battlefield. Armor & Mobility promotes critical thought and debate across defense, government and industry using information from field lessons learned and commercial best practices.

The Boeing Company - Booth # 613: Boeing is the world's leading aerospace company and largest and most versatile manufacturer of commercial and military aircraft. Boeing designs and manufactures aircraft, electronic and defense systems, missiles, satellites and advanced communication systems. Boeing also is a major service provider to NASA for the space shuttle and International Space Station.

Think-A-Move, Ltd. - Booth # 311: Think-A-Move's SPEAR™ Speech Recognition System provides unsurpassed device control and communications capabilities. SPEAR's applications include control of unmanned systems and command operations centers, and speech transcription. Communications applications include tactical communications headsets for the military and first responder markets, and Bluetooth cell phone headsets for the consumer market.

TORC - Booth # 510: TORC enables engineers to rapidly integrate robotic systems through a suite of modular, customizable products. TORC's product line is used by leading academic, commercial and government organizations to shorten the development process, lower costs and mitigate risks. TORC provides solutions for drive-by-wire conversion, emergency stop, power management, autonomous navigation, and operator control, all of which were integrated onto the Ground Unmanned Support Surrogate (GUSS) vehicles for MCWL.

University of Michigan - GRRC - Booth # 214: The GRRC conducts research in autonomous ground vehicles and mobile robots through supporting programs in research and education. The GRRC projects are primarily sponsored by the US Army's Tank-Automotive Research Development and Engineering Center (TARDEC). The University of Michigan leads the GRRC, which also includes partners from other academic institutions as well as industry. The GRRC is located at 1100 H.H. Dow Building, on the North Campus of the University of Michigan in Ann Arbor.

Vecna Technologies - Booth # 317: Vecna Robotics provides the world's most intelligent, powerful, precise, and energy-efficient robotic manipulation solutions to support demanding military applications which include logistics, hazardous duty, and rescue operations.

iRobot: The Robot Company iRobot®

iRobot designs and builds robots that make a difference – on the land and in the water.
Founded in 1990, iRobot has more than two decades of experience at the forefront of the global robot industry.

iRobot's government and industrial robots provide enhanced situational awareness, reduce risk and increase mission success.

iRobot's combat-proven unmanned ground vehicles (UGVs) protect those in harm's way and save lives every day; more than 3,500 have been delivered to military and civil defense forces worldwide. 310 SUGV (Small Unmanned Ground Vehicle), the robot for dismounted EOD missions, and 320 SUGV, the robot for infantry soldiers, perform search, reconnaissance, bomb disposal and other dangerous missions. SUGV is a smaller, lighter version of the iRobot® 510 PackBot®, one of the most successful battle-tested robots in the world. A modular, mission-configurable robot, PackBot is quickly reconfigured based on the needs of the mission and the operator's preferences.

iRobot's unmanned underwater vehicles (UUVs) perform multiple missions for oceanographers, maritime researchers and military planners, including physical, chemical and biological oceanography, tactical oceanographic surveys and marine environmental monitoring.

iRobot's Research Group performs cutting-edge research to meet the advanced needs of sponsors with integrated robotic solutions. AVA, a prototype of one of the world's most advanced mobile robotics platforms, uses multiple sensors for autonomous self-navigation and a tablet-based interface.

iRobot's goal is to drive innovation, serve as an industry catalyst and change the world by fueling the era of robots. As a leader in the global robot industry, iRobot remains committed to providing platforms for invention and discovery, developing key partnerships to foster technological exploration and building robots that improve the quality of life and safety standards worldwide.

QinetiQ North America's Technology Solutions Group Overview QinetiQ North America

QinetiQ North America's Technology Solutions Group (TSG) provides a wide range of aerospace, defense and security products and services to the defense, civilian government and commercial markets. Headquartered in Reston, VA, TSG has a nationwide presence to support two primary program areas in Land Systems and Maritime & Transportation Systems. TSG focuses on high technology R&D and the rapid development of concepts into proven products and services.

Land Systems programs include a comprehensive suite of survivability and unmanned ground system solutions. Survivability products include vehicle armor, hybrid electric drives for ground combat vehicles, RPG nets and gunfire detection systems. Unmanned ground systems include a complete set of robotic solutions for military, reconnaissance, security and first responder applications. TSG also provides force monitoring solutions such as vital statistics and geo-location tracking of mobile teams.

Maritime & Transportation programs include aircraft carrier launch and capture systems, air traffic management systems, perimeter and critical infrastructure security, maritime unmanned systems, asset monitoring and supply chain management. TSG also provides oceanographic and mapping solutions, as well as maritime and transportation systems integration and support services.

QinetiQ North America's Technology Solutions Group solves technology challenges for aerospace, defense and security customers worldwide. TSG identifies solutions and brings new products to market in record time. Their products and services save lives and make it easier to monitor, manage and protect complex systems and critical assets. TSG provides proven technology solutions and they listen to their customers to make great products and services even better. TSG's solutions are modular and scalable to provide a wide variety of options to a diverse customer base. Visit TSG online at www.qinetiq-na.com.

NOTES:

NOTES:

MARK YOUR CALENDARS & JOIN US AGAIN IN 2012!

2012 Ground Robotics Capabilites Conference & Exhibition
San Diego, CA

Sheraton San Diego
March 21-23, 2012

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Ground Robotics Capability Conference and Exhibit

ONR Code 30 Autonomy Science and Technology Efforts

Mr. Michael Bruch
Code 30 Autonomy Lead
Office of Naval Research

23 March 2011

NAVAL RESEARCH

ONR S&T Departments

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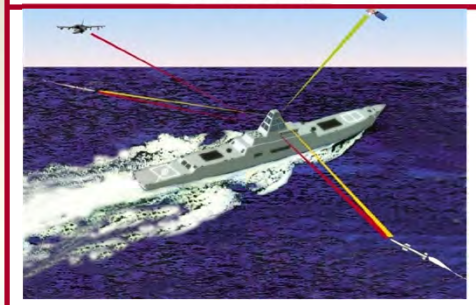
Expeditionary Maneuver
Warfare & Combating Terrorism

Code 31

C4ISR



Code 32

Ocean Battlespace Sensing

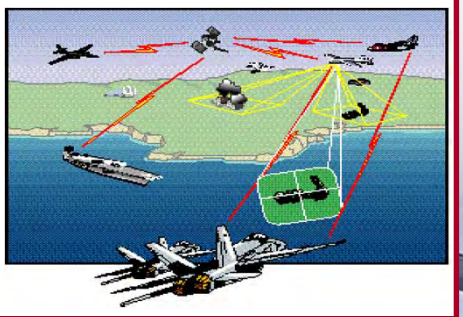
Sea Warfare and Weapons

Code 33

Warfighter Performance

Code 34

Air Warfare and Weapons



Code 35

ONR 30 Autonomy Mission Statement

To move Unmanned Ground Systems from tele-operation and brittle autonomy to systems with reliable long-range autonomy and intelligent behavior models to reduce operator workload.

In addition to being more capable, the autonomy package must ultimately be affordable for the USMC. This requires investments in low-cost high-performance perception systems with full day/night capability, advanced world modeling and motion planning techniques, robust pose and localization algorithms, intelligent and adaptive behavior models, and innovative human-robot interaction models.

ONR 30 Autonomy Objectives

Increase Capability:

Provide Marines with highly autonomous systems designed to support widely distributed small units with logistics and close follower support

- Complex terrain navigation and environmental-context understanding
- 24-hour poor-weather operation
- GPS-denied navigation capability over long-range missions
- Real-time adaptive autonomous behavior generation
- Intuitive Marine-UGV interaction

Decrease Cost:

Develop solutions that will not only provide a positive cost-benefit but also fit within the increasingly constrained budget of the DoD

- Affordable sensor suites and computation architectures
- Easily tunable perception and autonomy algorithms for new environments and platforms

ONR UGV Autonomy Technology Areas of Interest

Specific Technology Areas of Interest:

- Cognitive models for adaptable autonomy, enhanced user interface, trust, and anticipation
- Context-based reasoning
- Day/night perception
- True 3D terrain traversability and planning
- Sensor fusion for robust perception
  - Fusion of multi-modal low-cost sensors
- Robust multi-sensor relative-localization techniques
- GPS-denied absolute-localization techniques
- Advanced world modeling

Other S&T barriers to UGV autonomy capability and cost?

ONR UGV Target Mission Areas

Target UGV Missions:

- **Logistics Connector**

  Highly autonomous logistics resupply platform in support of large numbers of widely distributed Marine small units.

- **Autonomous Wingman**

  A close-follower platform with warfighter-focused autonomy in support of dismounted Marines to lighten the load, perform CASEVAC operations, and close combat support.

How to contact ONR

For more information about ONR:

http://www.onr.navy.mil/

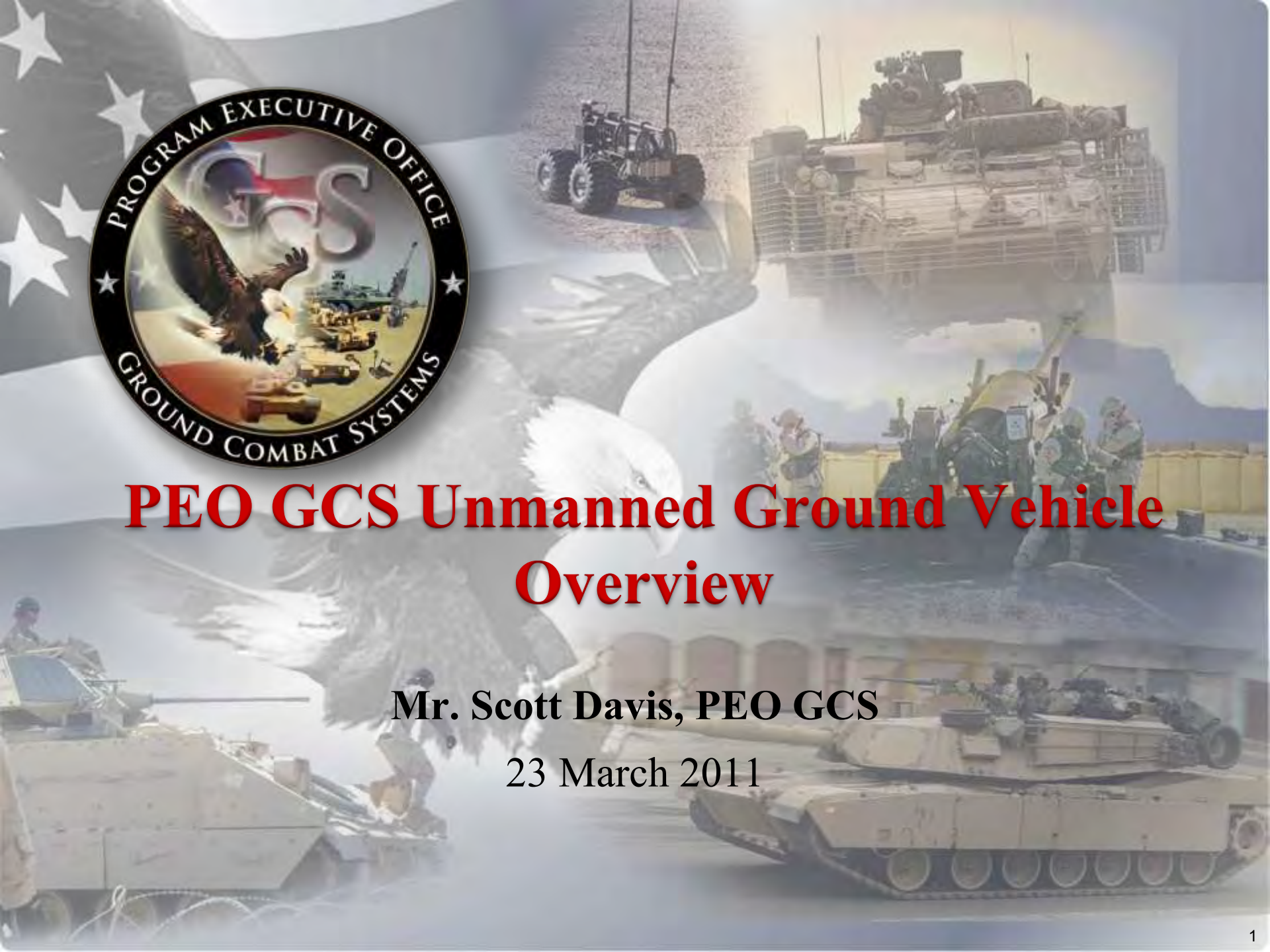
For more information on ONR Code 30
Unmanned Ground Systems:

http://www.onr.navy.mil/Home/Science-Technology/Departments/Code-30.aspx

To submit a white paper:

http://www.onr.navy.mil/

Click on “Contracts and Grants”
Click on “Broad Agency Announcements”
Select “BAA11-001”



PEO GCS Unmanned Ground Vehicle Overview

Mr. Scott Davis, PEO GCS

23 March 2011

Outline

- Program Executive Office for Ground Combat Systems (PEO-GCS) Overview
- Strategic Environment
- PEO-GCS Robotic Systems Currently in Combat
- Accomplishments and Warfighter Support
- Developing Systems
- Emerging Requirements
- Alignment with ARFORGEN
- Key Questions/Challenges
- Way Ahead/Opportunities

PEO Ground Combat Systems

As of 25 January 2011

PEO
Mr. Scott Davis

DPEO
Dr. Paul Rogers

Executive Officer (PEO)
LTC Chris Ford

Executive Office Manager (PEO)
Debbie LaFleur

Executive Assistant (DPEO)
Ann Ricci

APEO Human Capital
Kristi Sharp

APEO Chief Information Office
Don Papke

APEO Logistics & International
Ken Seibel

APEO Business Management
Tony Misuraca

APEO Operations
Bryan McVeigh

APEO Systems Engineering & Integration
Tony Desmond

APEO Strategic Management & Communications
April Louis

ASA(ALT) Soldier Maneuver Systems (SMS) Directorate

Vacant, Director SMS
David Nelson Deputy Director (Acting Director)
(Bradley/M113) – LTC Lamar Hall
(Artillery) – Mr. Ed Murray
(Abrams/M88) – Mr. Steve Thorson
(Stryker) – Mr. Norm Stuckey
(Stryker/Robotics) – Mr. Steve Campbell
(GCV) – MAJ Scott Everton
(GCV) – Mr. Chad Stocker

Heavy Brigade Combat Team
PM COL W. Sheehy
DPM Mr. K Houser

Stryker Brigade Combat Team
PM COL R. Schumitz
DPM Ms. C. Tucker

Ground Combat Vehicle
PM COL J. DiMarco
DPM Mr Marlin Carlsen

Robotic Systems JPO
PM LtCol D. Thompson (USMC)
DPM Mr. J. Jaczkowski

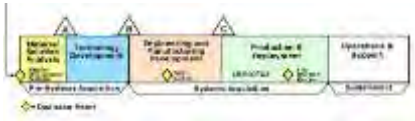
PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS

OUR MISSION IS OUR WARFIGHTERS' FUTURE

Strategic Environment

- **Operational**
  - Persistent conflict
  - Hybrid threats requiring hybrid solutions
  - Advanced/improvised technologies targeted against combat vehicles

- **Budget**
  - Pressure to cut defense & other spending
  - Topline base budget expected to have modest, but steady growth
  - "Do more without more"



- **Army Modernization**
  - Interoperability, Commonality, Affordability
  - BCT-centric
  - Buy fewer, more often
  - Incremental fielding of capability thru ARFORGEN

- **Acquisition Reform**
  - Increased competition throughout acquisition process
  - Reduced tolerance for cost/schedule risk
  - Revised Milestone certification reqs

Uncertainty, Complexity, and Constant Change

Where is the Army going?

Equipment Modernization Imperatives

- **Versatile:**
  - Formations that are tailorable
  - Equipment that is adaptable and capable of growth
- **Networked**
  - Increased situational awareness, force protection, and command and control on the move down to the individual Soldier
- **Affordable**
  - Evolutionary and incremental modernization
  - Balanced investment between current operational needs and future requirements
  - Long-term affordability

The Army seeks to develop and field a ***versatile*** and ***affordable*** mix of equipment to allow Soldiers and units to succeed in full spectrum operations today and tomorrow

Evolution of Ground Robotics in Combat

Sustainment, Modernization, Interoperability and Modularity

2004
162 systems
- No single vendor could produce 162
- 5 vendors, multiple configurations
- Joint effort, EOD focused

2005
1800 systems
- Robot's proven ability to save lives
- Expansion beyond EOD mission (Countermine, Security)
- Agreements w/ AMC and REF

2006
4000 systems
- Engineers and Infantry
- Route clearance, Explosive detection & Weaponization development

2007
5000 systems
- Special Forces robot applications assessed
- Route clearance, Explosive detection & Weaponization on battlefield

2008
6000 systems
- Maneuver elements
- Range extension
- CBRNE detection
- Persistent surveillance
- RC HMMWV
- More capable payloads

2009-2010
7000 systems
- Military Police
- Smaller platforms
- Enhanced battery life
- Commonality
- Remote deploy
- More capable payloads

2011-Future
- Interoperability
- 'Plug & play' capabilities
- Limited autonomy
- Weaponization
- Increased agility and dexterity

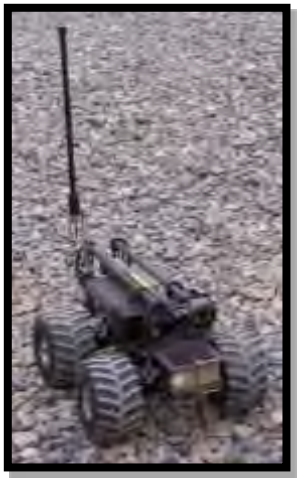
Almost one third of robots issued to units in 2009-2010 went to units other than EOD and Combat Engineers.

PEO-GCS Robots Currently in Combat

Mini-EOD (SUGV-310) **(260)**

PackBot Family **(1100)**

MARCBot **(350)**



TALON Family **(1000)**

M160 **(40)**

PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS

OUR MISSION IS OUR WARFIGHTERS' FUTURE

PEO-GCS Robots Currently in Combat

- **Robotic Fleet Management**
  - 2700 Robots deployed in theater
  - RS JPO provides support directly to the Warfighter through:
    - Joint Robotic Repair and Fielding (JRRF) Activity CONUS
    - Joint Robotic Repair Detachments (JRRDs) OCONUS

PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS

OUR MISSION IS OUR WARFIGHTERS' FUTURE

Accomplishments and Warfighter Support

- Stand-off for interrogation and blow in place
- Deploy and operate from inside route clearance and other vehicles
- Entry control points
- M160 Successes
  - Adaptations for new uses
  - Route clearance

PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS

M160 video

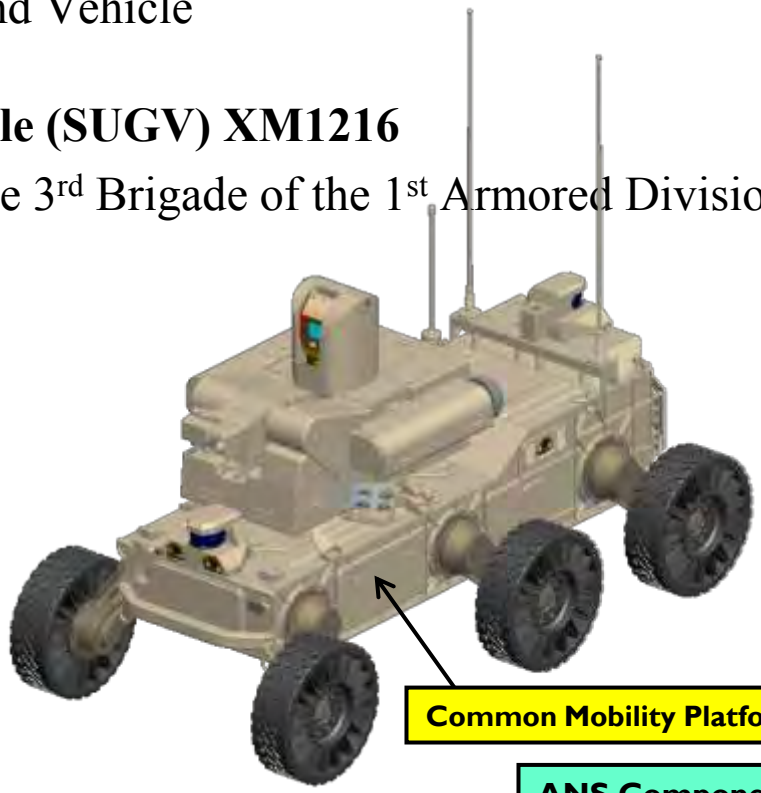
Funded Systems in Development

Common Mobility Platform (CMP) and Lethal Variants

- Autonomous Navigation System (ANS) has demonstrated "stand-alone" capabilities – potential to use as common robotic appliqué to enable scaleable autonomy for existing platforms
- Potential to leverage capabilities for multiple platforms and future Multi-Mission Unmanned Ground Vehicle

Small Unmanned Ground Vehicle (SUGV) XM1216

- First Unit Equipped will be 3rd Brigade of the 1st Armored Division scheduled in April 2011



Emerging Requirements

- **Multi-Mission Unmanned Ground Vehicle (MMUGV)**
  - Over 80% Common with CMP/ANS currently in development
- **Squad Multi-purpose Equipment Transport (SMET)**
  - High mobility, semi-autonomous, small-unit equipment transport
  - Battery recharging
- **Autonomous Mobility Appliqué System (AMAS)**
  - Create "optionally-manned" or unmanned systems with current manned vehicles
  - Common A-kit for scaleable autonomy/control

Alignment With ARFORGEN

- **Forces Command (FORSCOM) Home Station Training Initiative**
  - Robotic training lanes and repair capabilities at multiple CONUS sites
- **Training and Doctrine Command**
  - Institutionalize across DOTMLPF and integrate into force structure
- **Fielding Through Joint Urgent Operational Needs Statements (JUONSs), Operational Needs Statements (ONSs) and "10 Liners"**
  - COTS systems currently in the fight
  - CDRT process for transition to PORs
  - Limited success to date
- **XM1216 Increment 1 Fielding**
  - Brigade sets 1-3 approved

PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS

OUR MISSION IS OUR WARFIGHTERS' FUTURE

Unmanned Ground System Modernization Strategy

Modularity, Commonality and Interoperability

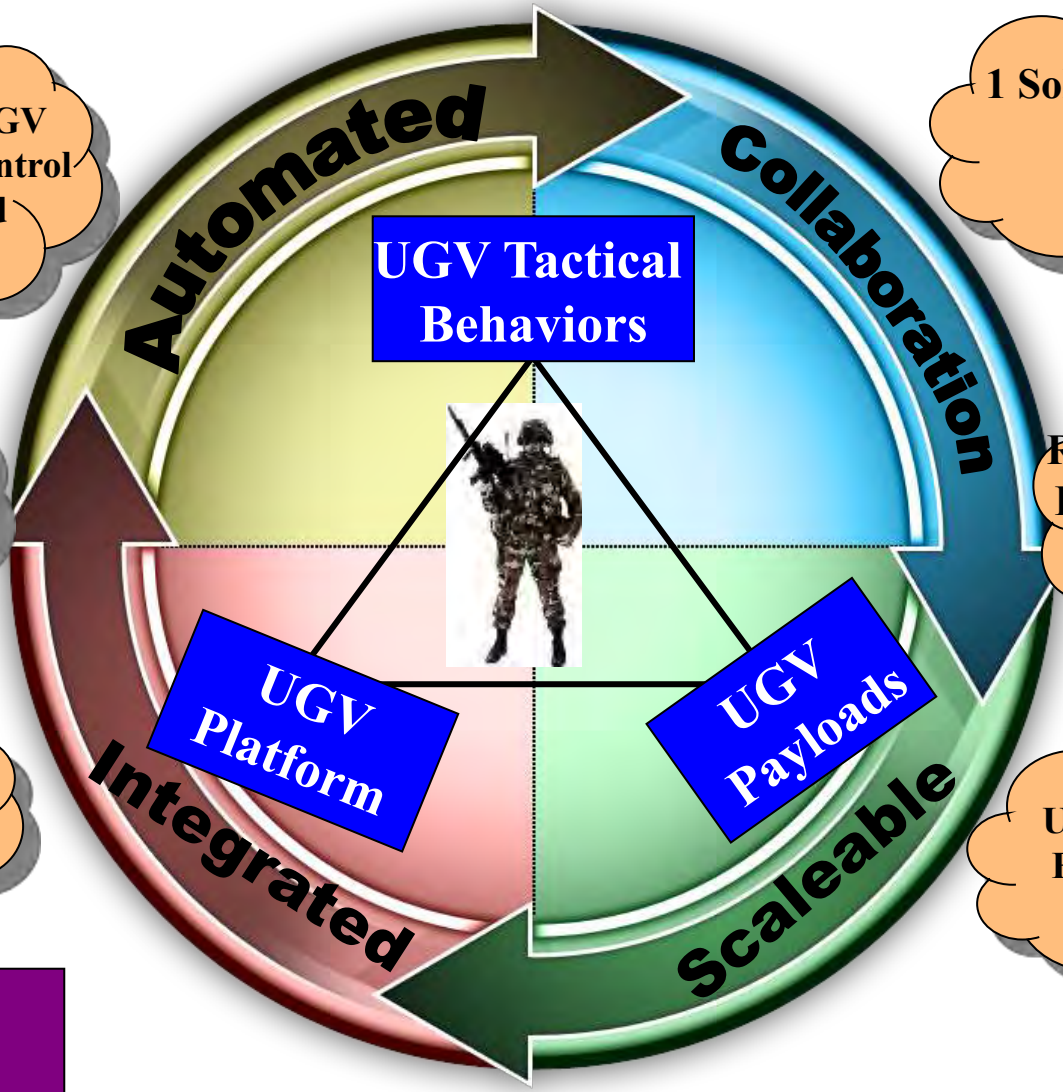
PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS

1 Soldier to 1 UGV Teleoperation Control Some Limited Autonomy

Robots doing dull, dirty, dangerous jobs

UGVs providing Standoff protection

Today



1 Soldier to Many UGVs nearly autonomous

Robots doing tasks, Better, faster, safer, &more efficient

UGV-UAS Teaming For Full Spectrum Operations

Future

OUR MISSION IS OUR WARFIGHTERS' FUTURE

Key Questions/Challenges for the Robotics Community

- **How do we capture and convey the Voice of the Customer?**
  - Robotics will become ubiquitous across domains
- **Require a consolidated strategy to drive common solutions**
- **Resource constrained environment**
  - Congressional mandate of 1/3 unmanned by 2015
  - Efficiencies through consolidation
  - Leverage one time investments across multiple weapon systems
- **Coordination with automotive industry**
  - Legal and infrastructure challenges
  - Economies of scale
- **Armed robots**
  - Laws of War, ethical issues, and public perception

PROGRAM EXECUTIVE OFFICE GROUND COMBAT SYSTEMS

Way Ahead/Opportunities

- **Interoperability and Commonality goals**
  - Interoperability profiles – industry participation
  - Promotes modularity
  - Promotes competition
  - Reduces logistics burden

- **Partnering between Defense and Industry**
  - NDIA, AUVSI, RTC are all good examples

PROGRAM EXECUTIVE OFFICE
GROUND COMBAT SYSTEMS

OUR MISSION IS OUR WARFIGHTERS' FUTURE

CTTSO Remote Procedures Programs Brief

Ground Robotics Capabilities Conference and Exhibition
March 24,2011

Combating Terrorism Technical Support Office

CTTSO Organization

Special Operations/Low-Intensity Conflict & Interdependent Capabilities

Combating Terrorism Technical Support Office

Department of State

Technical Support Working Group

Explosive Ordnance Disposal/ Low-Intensity Conflict

Irregular Warfare Support

TSWG Organization

Subgroup Mission

Mission: Identify, prioritize, and execute research and development projects that satisfy mission critical needs, fill capability gaps, and **address** interagency **requirements** for advanced technologies to safely and effectively **defeat improvised terrorist devices.**

Membership:

- Department of Defense
- Department of Homeland Security
- Department of Energy
- Department of State
- Department of Justice
- Intelligence Community
- National Bomb Squad Commanders Advisory Board
- Federal, State and Local Bomb Squads

"I want to plead guilty and 100 times more" Faisal Shahzad

CTTSO Robotics

ARTS/TRAP

Micro Air Vehicle

MAARS

Land Shark

Vanguard MKII

Warrior

RUCK

BomBot

Power Hawk Integration

OBJECTIVE: Integrated the Power Hawk Rescue System as a Vehicle Borne IED (VBIED) access tool for onto the ANDROS F6A robotic platform

END USERS: USAF EOD, Civil Bomb Squads

DELIVERED: 8 Power Hawk Systems

SUCCESS: 113 first responder systems sold totaling **$3.39M**

PERFORMER: NORTHROP GRUMMAN Remotec

Affordable Robust Mid-Sized Unmanned Ground Vehicle

OBJECTIVE: Develop a low cost, robust, mid-sized UGV for Defense and Homeland Security app

CAPABILITIES:

- Remotely provides reconnaissance, tool delivery and disruption capabilities
- Utilizes JAUS communication architecture
- Plug and play payload deck
- Extended run time w/ generator
- Arm Reach 40” below ground
- End Cost 50K (Base Chassis)
- Uses Energid’s Actin Arm Control

END USERS: USAF EOD, Civil Bomb Squads, Customs and Border Patrol

PERFORMER: Black i

Robotic Mobility Platform (RMP 400)

OBJECTIVE: Enhance the Segway RMP 400 capabilities by integrating multiple sensors under a JAUS common architecture.

CAPABILITIES:

- Provides remote reconnaissance, sensor delivery and disruption capabilities
- Utilizes JAUS architecture
- Sensors include: Joint Chemical Agent Detector, ADM 300 Radiation Detectors, GR 135B Isotope Identifier, and the DFU 100 Dry Filter Unit, Multi-Rae Gas Detector an Ahura First Defender XLS3
- End Cost 46K (Base Chassis)

END USERS: USAF EOD, PFPA

PERFORMER:

SEGWAY Robotics

Advanced Manipulators for VBIED

OBJECTIVE: Develop improved manipulator end effectors/grippers for robotic platforms that provide enhanced dexterity

CAPABILITIES:

- Utilizes JAUS communication architecture
- Automatic Tool Changing
- Tools carried onboard RCV
- Tools designed for VBIED Recon include:
  - Drill, Video scope, Soft Shears, Pinch Gripper, Parallel Gripper, Side Cutter
- Additional program integrates with F6A as possible upgrade path

END USERS: USAF EOD, Civil Bomb Squads, PFPA, FBI

PERFORMER: re2 NORTHROP GRUMMAN Remotec

Camera Boom

OBJECTIVE: Provide a tool to extend the reconnaissance capability of robotic platforms used by the military and public safety bomb technician community.

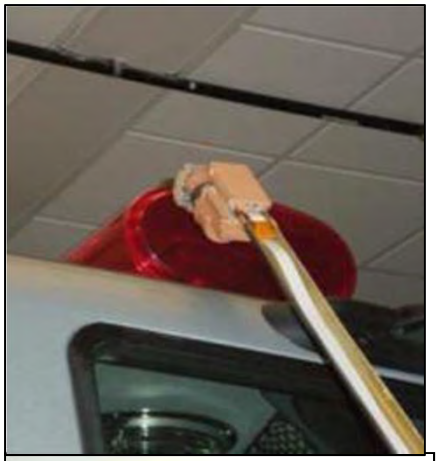
CAPABILITIES:

- Extend Camera reach 8 Ft Horizontal, 11 feet vertically
- Viewed through OCU
- Additional sensor payload capable

END USERS: Joint Service EOD, Civil Bomb Squads

PERFORMER:

ARA



Body Bomb Tool Kit

OBJECTIVE: Develop a set of tools that can be changed and operated remotely that address the specific threat of an explosive device attached to an individual.

CAPABILITIES:

- Totally mechanical
- Tool Changing at Crisis site
- Tools carried onboard RCV
- Tools designed for person Borne IED/IED
- Kit consist of 15 tools
- Initial installation on Andros F6A/Wolverine and Black I Land Shark

END USERS: USAF EOD, Civil Bomb Squads, PFPA, FBI

PERFORMER: Israeli National Police

Agile AWE

OBJECTIVE: Enhance development of the AWE frequency agile radio system to address the needs of military SOF and EOD personnel as well as those of the Law Enforcement SWAT and Public Safety Bomb Technician communities.

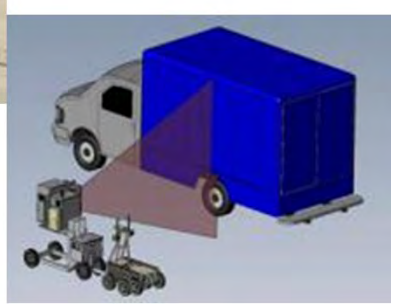
CAPABILITIES:

- The Agile AWE is a compact two radio, frequency agile, MIMO mesh router
- The Agile AWE is able to shift radio frequencies in order to find the optimal frequency for any situation
- Operating frequencies can be changed on the fly in software

- **END USERS: JSEOD**
- **PERFORMER:** NOMADIO

Advanced X-Ray Imaging Single-Sided System (AXISS)

OBJECTIVE: Develop a system capable of obtaining an internal X- Ray image of the target from a single side and be deployed by a small robot.



CAPABILITIES:

- Remotely employed
- Uses a scan to Backscatter X-Ray internal components
- 2 minute scan, increase for higher resolution
- Current phase integrates the robotic interface and prototype delivery

END USERS: USAF EOD, Civil Bomb Squads, PFPA, FBI

PERFORMER: AS&E

Summary

- CTTSO has a long history developing robotic solutions for various communities
- User-focused approach to IED Defeat
- Solutions for both military and civilian bomb technicians
- Leveraging interagency and international partnerships

Contact information:

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NIPR: edwin.bundy@cttso.gov

2011 Ground Robotics Capability Conference

OSD Perspective

Jose M. Gonzalez
OUSD (Acquisition, Technology & Logistics)
Deputy Director, Portfolio Systems Acquisition,
Land Warfare and Munitions

Discussion Topics

- OSD/AT&L Organization
- Budget Perspectives
- Acquisition Efficiency Initiatives
- Ground Robotics Acquisition Challenges

Secretary of Defense
Hon. Robert Gates

Deputy Secretary of Defense
Hon. William Lynn

Under Secretary of Defense for Acquisition, Technology & Logistics
Hon. Ashton Carter

Principal Deputy :
Hon. Frank Kendall

Secretary of the Army
Hon. John McHugh

Secretary of the Navy
Hon. Ray Mabus

Secretary of the Air Force
Hon. Michael Donley

Asst. Sec. of Defense (Acquisition)
Vacant

DASD, Portfolio Systems Acquisition
Mr. Dave Ahern

Director, Land Warfare & Munitions
Mr. Jose Gonzalez

Excerpts from Secretary Gates January 6, 2011 Speech

- America is at war and confronts a range of future security threats, it's important not to repeat the mistakes of the past by making drastic and ill-conceived cuts to the overall defense budget.
- At the same time, it is imperative for this department to eliminate wasteful, excessive and unneeded spending, to do everything we can to make every defense dollar count.
- The goal was, and is, to sustain the U.S. military's size and strength over the long term by reinvesting those efficiency savings in force structure and other key combat capabilities.

Excerpts from Secretary Gates January 6, 2011 Speech (cont'd)

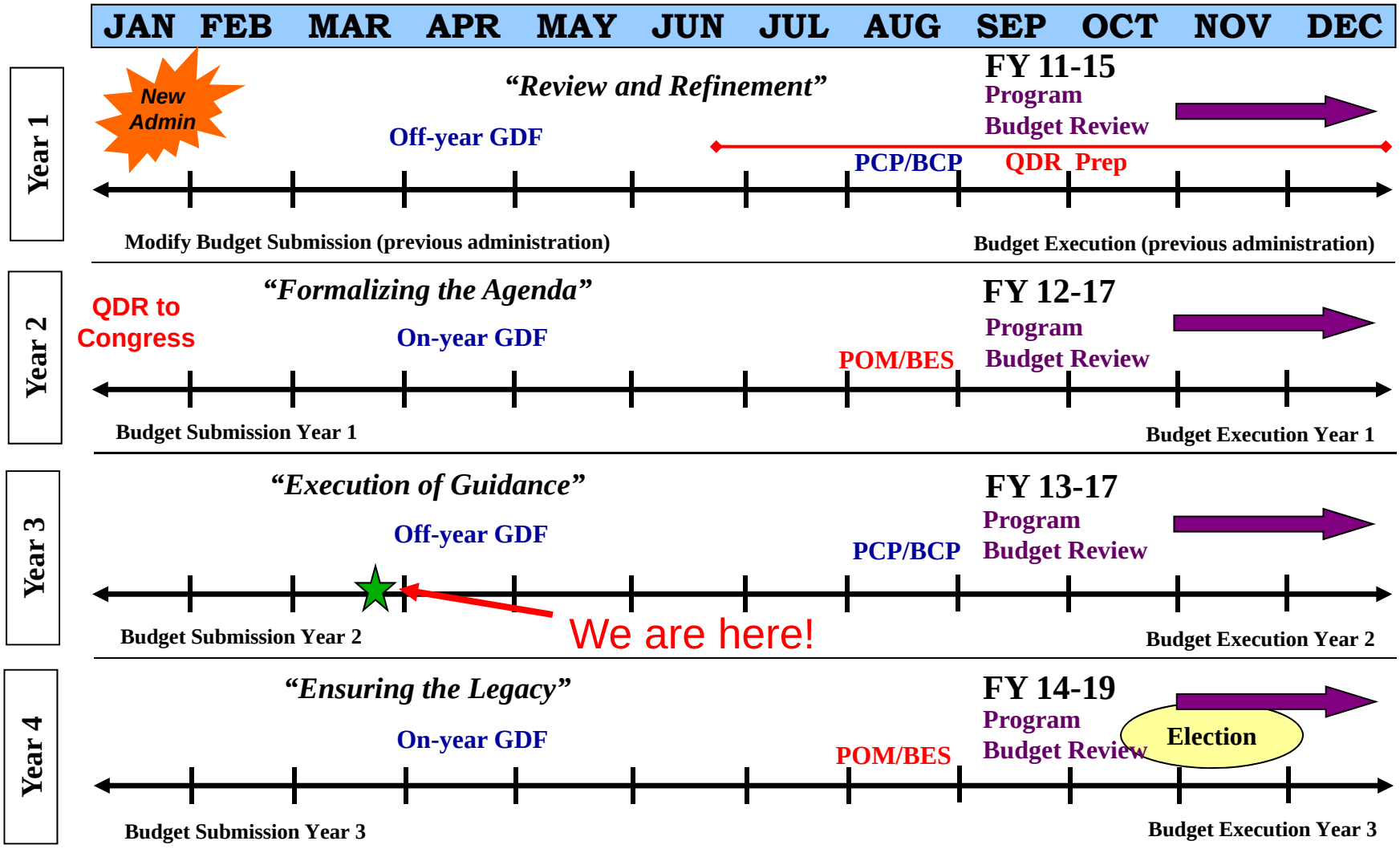
- Not every defense program is necessary, not every defense dollar is sacred and well spent, and that more of nearly everything is simply not sustainable.
- The Defense Department will continue to see real, albeit steadily diminishing, growth for the next three fiscal years before flattening out in the fourth and fifth year.
- What is important is to have a budget baseline with a steady, sustainable and predictable rate of growth that avoids extreme peaks and valleys in defense spending that can be enormously harmful to readiness, planning and financial management.

Mandate for Restoring Affordability and Productivity in Defense Spending (USD(AT&L) June 28, 2010 Memo)

- Deliver the warfighting capability we need for the dollars we have
- Get better buying power for the warfighter and taxpayer
- Restore affordability to defense goods and services
- Improve defense industry productivity
- Remove government impediments to leanness
- Avoid program turbulence
- Maintain a vibrant and financially healthy defense industry

Obtain 2-3% net annual growth in warfighting capabilities without commensurate budget increase by identifying and eliminating unproductive or low-value-added overhead and transfer savings to warfighting capabilities. ***Do more without more.***

Planning, Programming, Budgeting, and Execution



4 Administration Years with 2-year PPBE Cycle

Acquisition Efficiency Initiatives

- Target Affordability and Control Cost Growth
- Incentivize Productivity & Innovation in Industry
- Promote Real Competition
- Improve Tradecraft in Acquisition of Services
- Reduce Non-Productive Processes and Bureaucracy

Acquisition Efficiency Guidance Roadmaps

Target Affordability and Control Cost Growth

- Mandate affordability as a requirement
- Implement "should cost" based management
- Eliminate redundancy within warfighter portfolios
- Achieve Stable and economical production rates
- Manage program timelines

Incentivize Productivity & Innovation in Industry

- Reward contractors for successful supply chain and indirect expense management
- Increase Use of FPIF contract type
- Capitalize on progress payment structures
- Institute a superior supplier incentive program
- Reinvigorate industry's independent research and development

Promote Real Competition

- Emphasize competitive strategy at each program milestone
- Remove obstacles to competition
  - Allow reasonable time to bid
  - Require non-certified cost and pricing data on single offers
  - Enforce open system architectures and set rules for acquisition of technical data rights
- Increase small business role and opportunities

Acquisition Efficiency Guidance Roadmaps (cont'd)

Improve Tradecraft in Acquisition of Services

- Assign senior managers for acquisition of services
- Adopt uniform services market segmentation (taxonomy)
- Address causes of poor tradecraft
  - Define requirements and prevent creep
  - Conduct market research
- Increase small business participation

Reduce Non-Productive Processes and Bureaucracy

- Reduce frequency of OSD level reviews
- Work with Congress to eliminate low value added statutory requirements
- Reduce the volume and cost of Congressional Reports
- Reduce non-value added requirements imposed on industry
- Align DCMA and DCAA processes to ensure work is complementary
- Increase use of Forward Pricing Rate Recommendations (FPRRs) to reduce administrative costs

Technical Challenges

Robots have limited ability to:

- Perceive and understand situations under all conditions
- Predict behavior of teammates or aggressors
- Collaborate with humans and other robots
- Learn tasks and adapt to new situations
- Communicate effectively with other team members
- Move at near human speeds over any terrain
- Lift, maneuver and interact with physical objects

Non-Technical Challenges

- Operational, moral, ethical dilemmas
- Pockets of advocacy/no broad spectrum of acceptance
- Lack of stable/approved requirements
- Insufficient emphasis on the “illities”
- Inefficiencies created by duplicative activities for similar functions
- Coordination across current activities/domains is not robust
- No defined career paths and accepted advocacy for unmanned career path
- Cost-Benefits anecdotal

National Bomb Squad Commanders Advisory Board

Presentation to the

2011 Ground Robotics Capabilities Conference

March 24, 2011

David Heaven

Introduction

- Bomb Squad Robot Definitions and Requirements
- Robot Related Projects
  - Test Bed at Michigan State Police
  - VBIED Robot Standards Working Group at NIST
  - R&D Efforts

Deployed Robots Among U.S. Bomb Squads

Platform	Quantity
Andros F-6	**36**
Andros F-6A	**285**
Andros HD-1	**14**
Andros Mini-2	**55**
Andros MK V	**16**
Andros MK V-A1	**23**
Andros MK VI-A	**7**
Andros Wolverine	**15**
Icor Caliber	**5**
MURV-100	**5**
Other	**53**
Pedsco RMI-9	**24**
Talon	**30**
Vanguard MK-2	**46**

Robot Definitions in the National Guidelines for Bomb Technicians

Origin of Bomb Squad Robot Definitions

- NBSCAB responded to DHS FEMA requirements to define bomb squads (and all other responder groups) into a Type I, Type II, Type III,… format so that incident commanders could distinguish among various capability levels of resources being requested to support crisis events.
- NBSCAB steered this typing into a direction that would recognize bomb squads that were equipped to handle VBIEDs
- Based on this VBIED capability requirement, a need emerged to define a “VBIED capable robot.”
- Now the challenge is to provide some precise technical specifications to those definitions.

Robot Definitions in the National Guidelines for Bomb Technicians

***Unmanned Ground Vehicle (UGV):** A powered, mobile, ground conveyance that does not have a human aboard; can be operated in one or more modes of control (i.e., autonomous, semi-autonomous, teleoperation, remote control); can be expendable or recoverable; and can have lethal or non-lethal mission modules.

Teleoperation: A mode of continuous control wherein the human operator uses video feedback and/or other cues to directly control the actions of the UGV.

*As defined by the Joint Robotics Program Master Plan – 2004, published by OUSD (AT&L) Defense Systems/Land Mine Warfare and Munitions, 3090 Pentagon, Washington, D.C. 20301-3090.

Robot Definitions in the National Guidelines for Bomb Technicians

General Service Bomb Response Robot: A UGV capable of being operated in a teleoperation mode of control plus having a minimum:

- 300 feet range of operating distance from the human operator
- 2-hour mission duration without the need to replace/recharge the primary power source
- 6-inch obstacle clearance
- Outfitted with bomb disablement tools which includes, but not limited to:
  - Standard disrupter, with onboard aiming and firing capability
  - Mineral Water Bottle (MWB) or similar general type disruption tool with onboard firing capability
  - Manipulator Hand

Robot Definitions in the National Guidelines for Bomb Technicians

VBIED Capable Bomb Response Robot: A Bomb Response Robot that meets all of the requirements for a General Service Bomb Response Robot, plus capable of the following:

•Outfitted with a tool designed for breaking a side window in a passenger vehicle;

•Deploying, aiming and firing a PAN or similar gun type disrupter through the open window of a large sedan or Sport Utility Vehicle (SUV) and effectively engaging a package located at any position in the vehicle visible from the open window;

•Deploying and firing a MWB or similar general type disrupter through the open window of a large sedan or SUV and effectively engaging a suspicious package located at any position in the vehicle visible from the open window;

•Deploying and firing an overpressure disruption charge through the open window of a large sedan or SUV;

Robot Definitions in the National Guidelines for Bomb Technicians

VBIED Capable Bomb Response Robot: (continued)

•Operating it's manipulator through the open window of a large sedan or SUV at any position in the vehicle visible from the open window;

•Carrying, delivering, and firing a Bootbanger or similar ejection tool to a position underneath the trunk of a large sedan or SUV without the aid of a separate carrier;

•Deploying an ejection-type tool mounted on a separate cart alongside a target vehicle, such as the Modular Large Vehicle Disrupter (MLVD) or similar type disrupters**;**

•Being off-loaded from the bomb squad response vehicle, loaded with any one of the above weapon systems, and moved to a target 300 feet downrange within 20 minutes.

Options for VBIED Defeat Techniques

- Remote surgical disruption of a key circuit component
- Remote general disruption of the circuit
- Remote disassembly
- Remote attack focused on the main explosive charge (Expulsion tools)
- Manual attack

Development of these VBIED defeat options in 2009 placed an even greater burden on robot requirements.

Robot Definitions in the National Guidelines for Bomb Technicians

VBIED Capable Bomb Response Robot:

- **Disassembly Capable Bomb Response Robot**: (proposed) A Bomb Response Robot that meets all of the requirements for a General Service Bomb Response Robot, plus capable of the following:
  - Outfitted with a multipurpose interchangeable Spreader & Cutter Tool that uses non-energetic disassembly methods for responding to various threats and operations including VBIED, PBIED, package bombs, pipe bombs, hostage rescue, etc.
    - For VBIED response: Capability to gain access into vehicles, such as opening truck roll-up and trailer doors, opening vehicle side and rear doors, cutting vehicle posts and hinges, opening trunks and hoods, breaking window glass, etc.
    - *(There are additional sections for PBIED and other purposes, but not shown here.)*

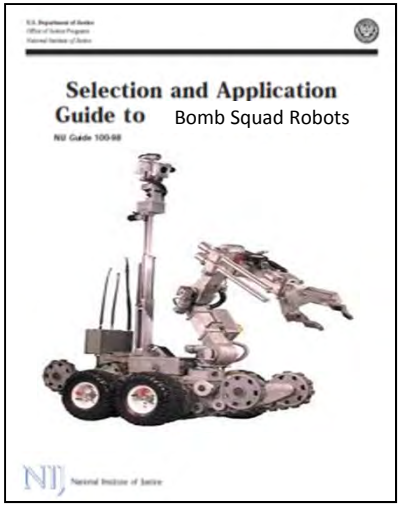
Response Robot Requirements Workshop for Vehicle Borne Improvised Explosive Device Applications

NIST
National Institute of Standards and Technology
Technology Administration, U.S. Department of Commerce

- An initial workshop was conducted January 26-28, 2011 at the NIST facility in Gaithersburg.
- Standard test methods are being developed to evaluate the performance of bomb squad VBIED capable robots.
- Bomb squads will be able to refine their requirements.
- Robot manufacturers will gain access to statistically significant performance data.

Development of Robot Standards

- NBSCAB will take the results from the NIST working group and work with NIJ to develop a Selection and Applications Guide, as the first step toward building bomb squad robot standards, with emphasis on VBIED capability.

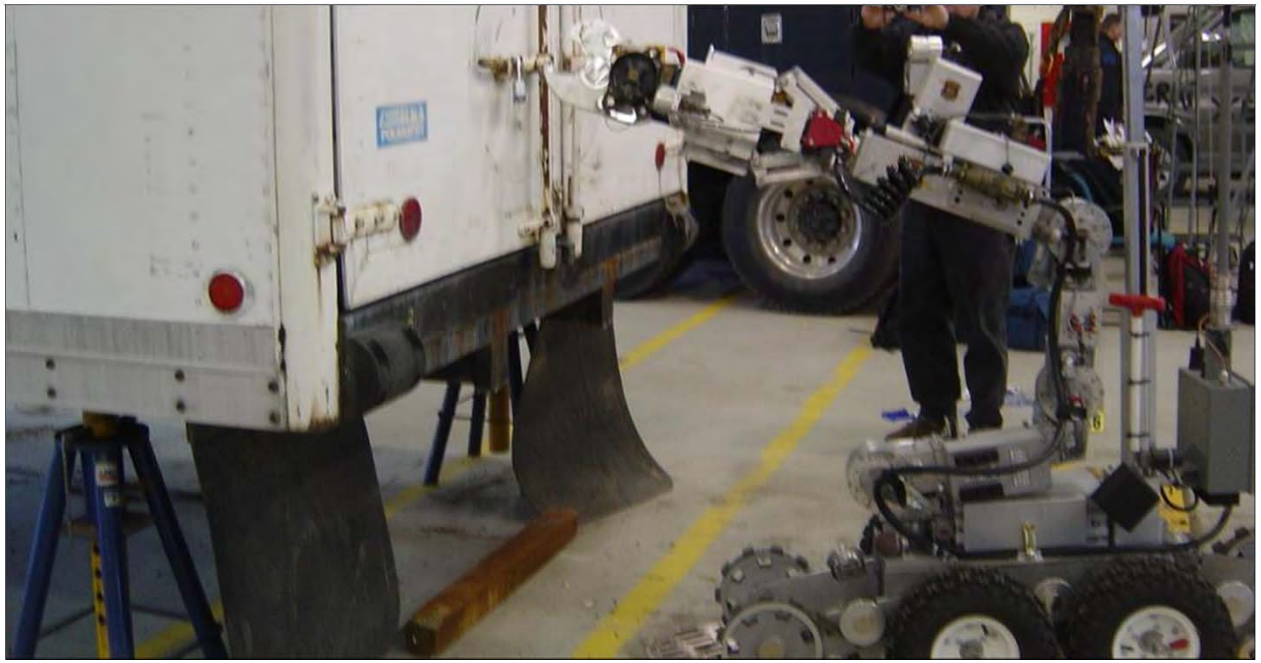


Critical Incident Response Technology Seminars (CIRTS)

- **Top Robot Requirements Identified in 2010**
- Ability to operate the RCV in a wireless mode w/o line of sight between RCV & OCU
- Ability of robot units to operate during missions in close proximity w/o interfering with each other
- Ability to deploy large vehicle access and disruption tools from the RCV. (Bootbanger, MLVD, etc)
- Ability to x-ray a suspect device through the robot and view image on the OCU
- Desire a fiberscope with a wide-angle view, and 10x zoom which is integrated for use by RCV.
- Ability to view the position of the platform, manipulator arm and end effector on the OCU monitor
- Ability to view the position of the platform, manipulator arm and end effector on the OCU monitor
- Ability to strengthen the robot arm when using heavy water charges
- Ability to have the pose and position of the Platform, manipulator arm and end effector displayed
- Desire a fiberscope with a wide-angle view, and 10x zoom which is integrated for use by RCV.
- Ability to strengthen the robot arm when using heavy water charges
- Desire maximum degrees of freedom and motion on all joints of the robot arm
- Ability to view from the end effector camera with the end effector in any position
- Ability to have remote plug and play modules
- Desire better dexterity articulation when using the gripper inside of a vehicle
- Ability to have multiple end effectors with different capabilities
- Ability to sense depth/distance from the OCU monitor.
- Desire better visualization under all light conditions from robot systems improved cameras
- Ability to deploy large vehicle access and disruption tools from the RCV. (Boot banger, MLVD, etc).

DHS S&T Test Bed at Michigan

Power Hawk
Non-Energetic Remote Access Tool "NERAT"



Power Hawk NERAT testing at Michigan State Police determined that it is an effective disassembly tool, capable of gaining access to cargo areas.

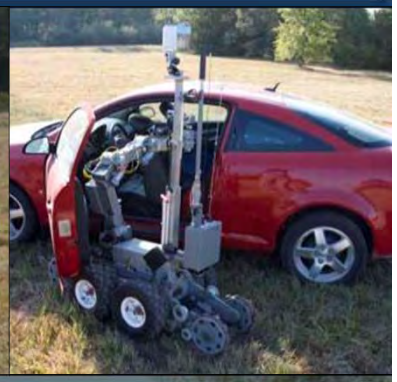
DHS S&T Test Bed at Michigan Robot Related Observations

- Mobility
  - Small Vehicles
  - Large Vehicles
- Strength
- Cameras
- Communications
- Manipulators and Tools
- Weapons
- Sensor Attachments
- Power
- Human Factors
- Reliability
- Other considerations

DHS S&T Test Bed at Michigan Robot Related Observations

<u>Sedans</u>

- Limitations within open door areas
- Large arms are limited within vehicles especially trunks and rear seats
- Challenges keeping trunks and doors open



<u>Trucks</u>

- Height challenges
- Cab surveillance
- Access to cargo area (locks and j-hooks)
- Truck cargo beds difficult to access
- Distant disablement shots within cargo areas
- Reading from a distance
- Getting robots into trucks

DHS S&T Test Bed at Michigan Robot Related Observations

Strength

- Manipulators such as Power Hawk (30+ lbs)
- Towing tools such as AXISS (350 lbs +)
- Opening and bending doors/trunks
- Lifting full containers (e.g. fuel containers)
- Carrying disablement charges (DEBIT, MLVD)

Weapons

- Dual disrupter mounts very useful
- Nearly always fired both disrupters on VBIED responses for access and disablement
- Weapons reduce mobility inside vehicles
- Targeting and distance measurement

DHS S&T Test Bed at Michigan Robot Related Observations

Mounting Sensors

- No standard placement methods or locations
- Optimization of sensor location and field of view
- Need for sampling tools
- Ability to transmit data

Camera Issues

- Obscurants: Dust, water drops, window glare, tinting
- Off-axis placement improves view but limits access
- Resolution for reading at a distance
- Low-light capabilities
- Visibility of targeting lasers
- Over watch cameras help to clearly view truck interiors
- Need for multiple operators to see each others' view

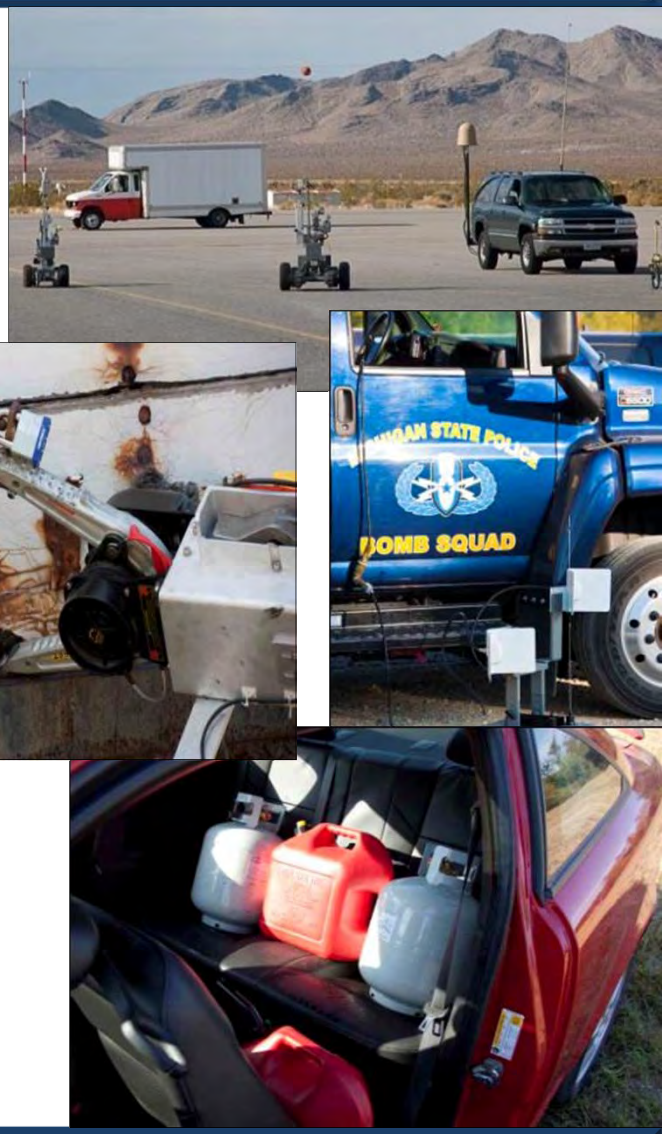
DHS S&T Test Bed at Michigan Robot Related Observations

<u>Communications</u>

- Range requirements in VBIED response
  - Long distances from ICP to target
  - Urban canyons
- Fiber Optic considerations
  - Length
  - Multiple robots and overlap of fibers
- Two way robot comms for downrange techs
- Difficulty getting frequency allocations
- Backbone for additional systems

<u>Manipulators and Tools</u>

- Variable end effectors
- Window breakers, etc
- Grabbing items within vehicles
- Limited mobility
- Opening locked and unlocked doors



DHS S&T Test Bed at Michigan Robot Related Observations

Power

- Response will likely be several hours long (potentially 5+)
- Response will involve long travel times from ICP to target (potentially 1000+ yards)
- Alternate power sources desirable
- Hybrids, Fuel Cells, Li-Ion batteries

Human Factors

- Dual robot operations
- Requirements for multiple robot training
- Human-Robot Interaction
- Navigation
- Perception & Intelligence

DHS S&T Test Bed at Michigan Robot Related Observations

<u>Reliability</u>

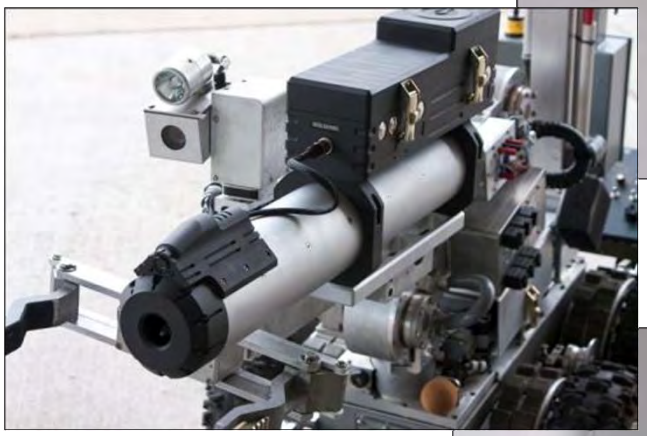
- Frequent breakdown even on well maintained robots
- Baseline Assessment
- Power supply
- Communications
- Thrown track
- Power Hawk
- Multiple broken arm gears

<u>Other Considerations</u>

- Improvised Situational Analysis
- Need a means of determining robot orientation to avoid overturning
- Audio to listen to sensors
- Potential for operations in spilled fuel

DHS S&T Project: TVEDS

Tactical Visual and Explosive Detection System

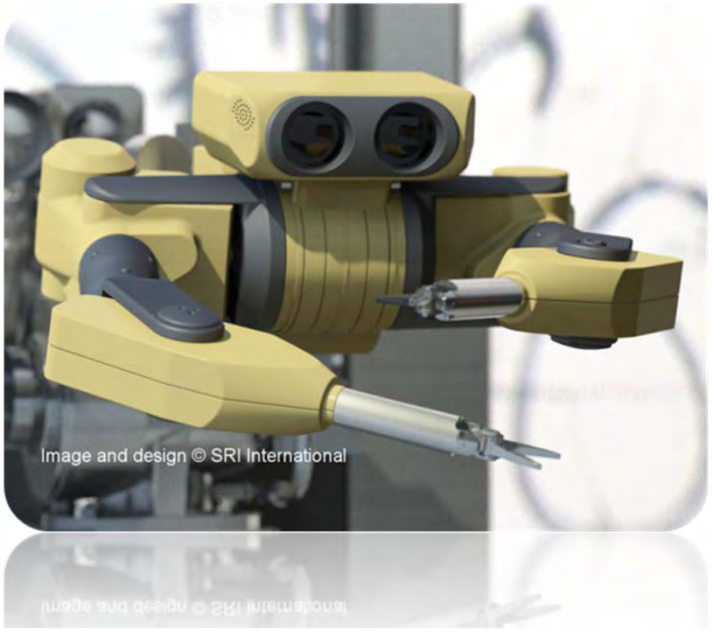


Ability to drill into a vehicle, insert video camera
Can be attached to the F6A and Wolverine Robot arm
Self-contained system with its own power and communications
Minimal signature or disturbance to the VBIED
Integrate with current counter IED tools

DHS S&T Project: Taurus

Intuitive Bomb Squad Dexterous Telemanipulator

- TAURUS is a revolutionary, low-cost, robust dexterous telemanipulation system developed with funding from DHS S&T for municipal bomb squad VBIED countermeasures.
- The bi-manual OCU with stereoscopic display will be key to user acceptance and high-performance telemanipulation. This system is based on technology used for robotic surgeries.

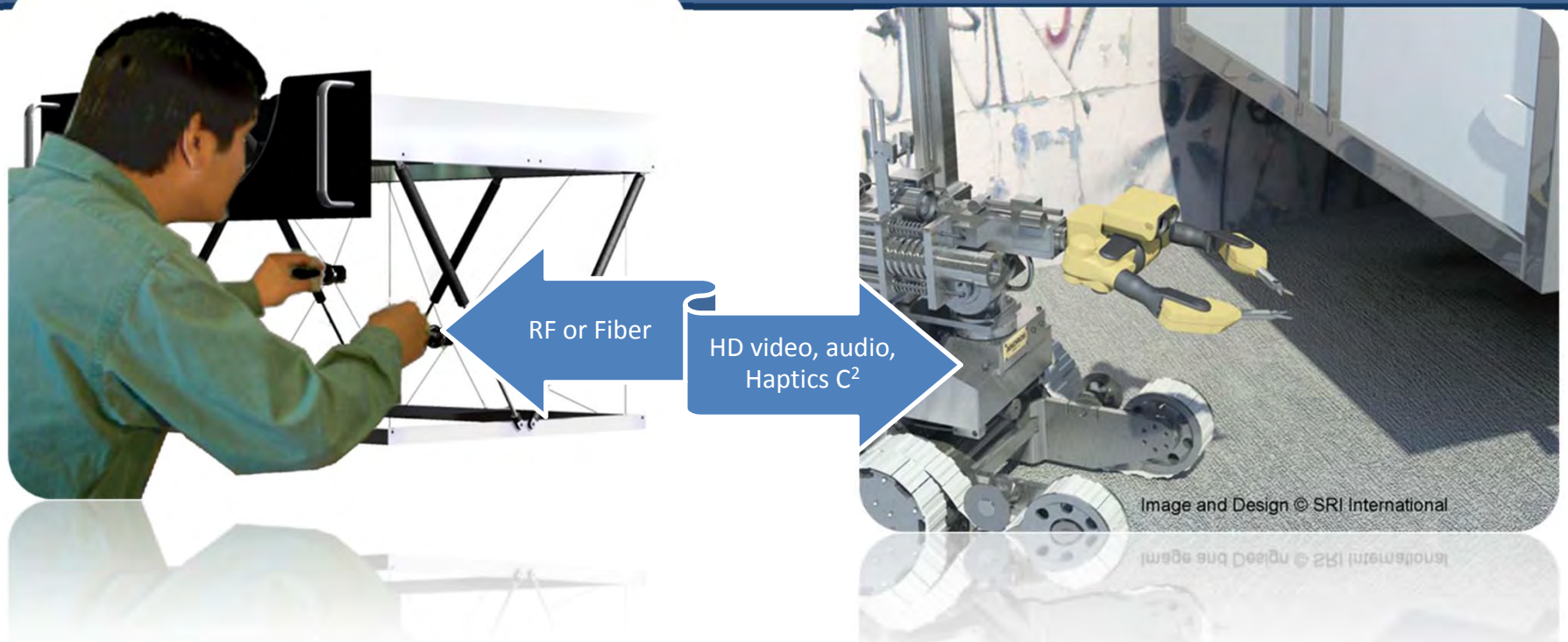


<u>Manipulator Features</u>

- 2 independently controlled 7 DOF robot arms
- Multi-functional cutter-graspers
- Stereoscopic HD camera w remote tilt-zoom-focus
- 5 pound payload. 42 x 33 x 33 in. workspace
- Modular and rugged design
- Compact 15 lb slave system weight
- Vehicle entry porthole size of 14”x5.2”
- Mounts to Andros F6-A or similar mobile EOD platform used by domestic bomb-squads

DHS S&T Project: Taurus

Intuitive Bomb Squad Dexterous Telemanipulator



Operator Control Unit Features

- Wireless digital RF link or fiber optic tether
- Portable 3D display with haptic feedback
- 3D haptic force, vibration and grip effort feedback through the arm control devices.
- Intuitive HRI adapted from SRI patented surgical robot enables effective manipulation performance.

Overall System Features

- Independent power, comms and OCU
- System production cost target of $30k

NBSCAB work with US Air Force on RONS Transfer to Law Enforcement

- US Air Force initiative to transfer RONS to civilian bomb squads, ATF, and FBI
  - First 7 robots have been successfully transferred
  - Process for turn-in and transfer now ready to move forward with turn-in of operational RONS
- Robots being transferred under 1997 National Defense Authorization Act, section 1033
  - Focus on getting counter IED and counter drug equipment to civilian law enforcement
- Benefits: reduces off-base responses for CONUS JSEOD; provides C-IED assets to our civilian bomb squads, leads to faster responses, better equipped bomb squads, more capable law enforcement agencies, ultimately leading to safer communities

Questions??

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www.nbscab.org

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Chief Roboticist Panel

Ground Robotics Capability Conference & Exhibition

Dr. Greg Hudas
U.S. Army RDECOM-TARDEC

Chief Roboticist Panel

"Saving Lives, Saving $ - Are Robot Recruits the Answer?"

Manned

Optionally Manned

Unmanned

The State of our Enterprise

Mr. Rob Maline
Enterprise Director, Joint Ground Robotics
robert.maline@osd.mil

24 March 2011

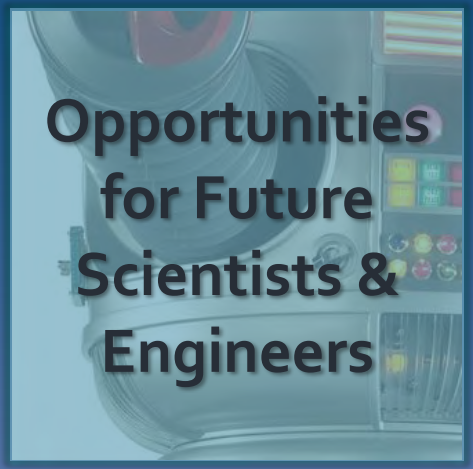
Agenda

- The State of Ground Robotics
- Discussing the Theme
- What's New with JGRE?

Robots are Here to Stay…

- Experiences in theater have proven that robotics can satisfy critical operational needs
- We have only just begun to understand how to leverage unmanned systems in the joint battle space…there will be more for robots to do in future warfare
- Robots allow war fighter presence in hostile environments at reduced risk of exposure and loss of life and limb

Our Enterprise is Healthy



Technology & Innovation

ATLAS, Cheetah & ARM (DARPA)

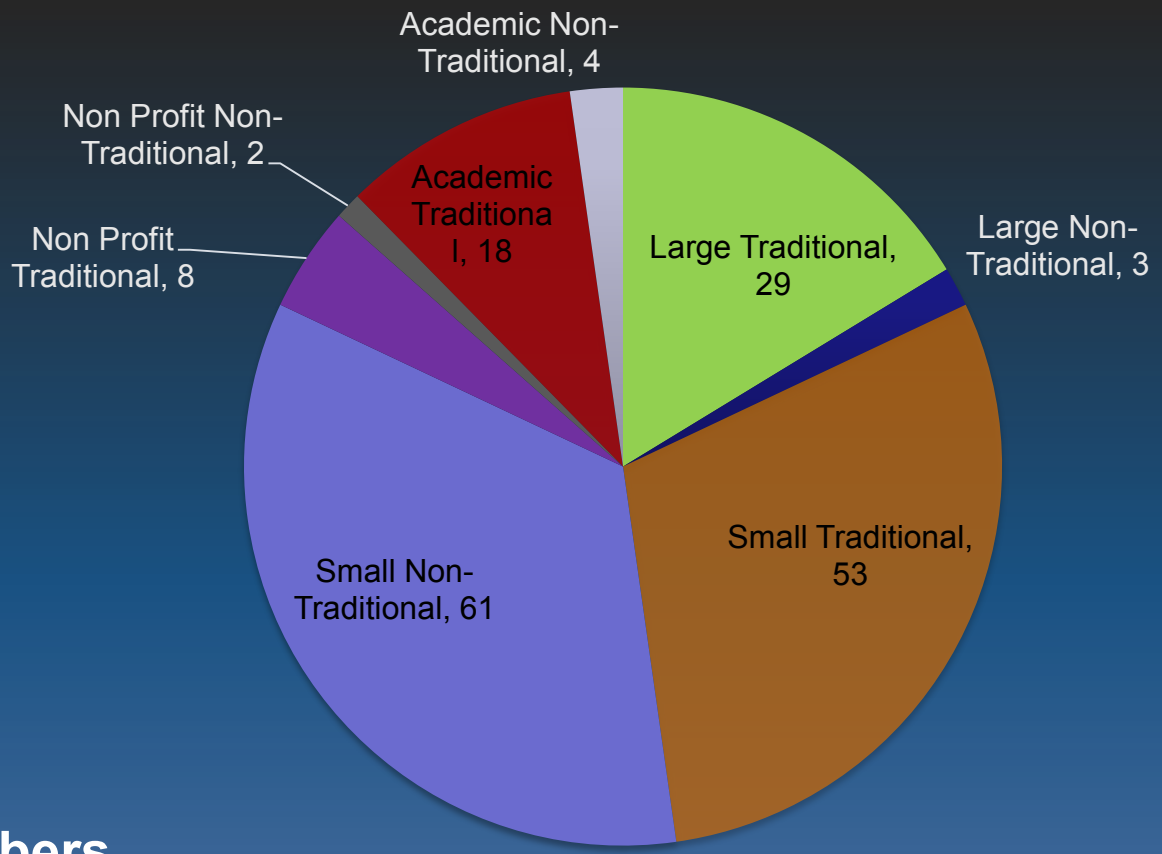
Urban Environment Modeling -UrbEm (JGRE)

Conformal End Effector (JGRE)

Robotics Technology Consortium

- Non-profit, Industry Organization
- Created in 2008 at the encouragement of the Joint Ground Robotics Enterprise
- Other Transaction Agreement (OTA) in place with LW&M/JGRE
- Consists of 178 large and small commercial companies, academic institutions, and non-profit organizations, both traditional and non-traditional
- Seeks to solicit and engage companies and organizations that may have not historically performed work for the Defense Department and other Government organizations in addition to traditional defense contractors
- http://www.roboticstechc.org/

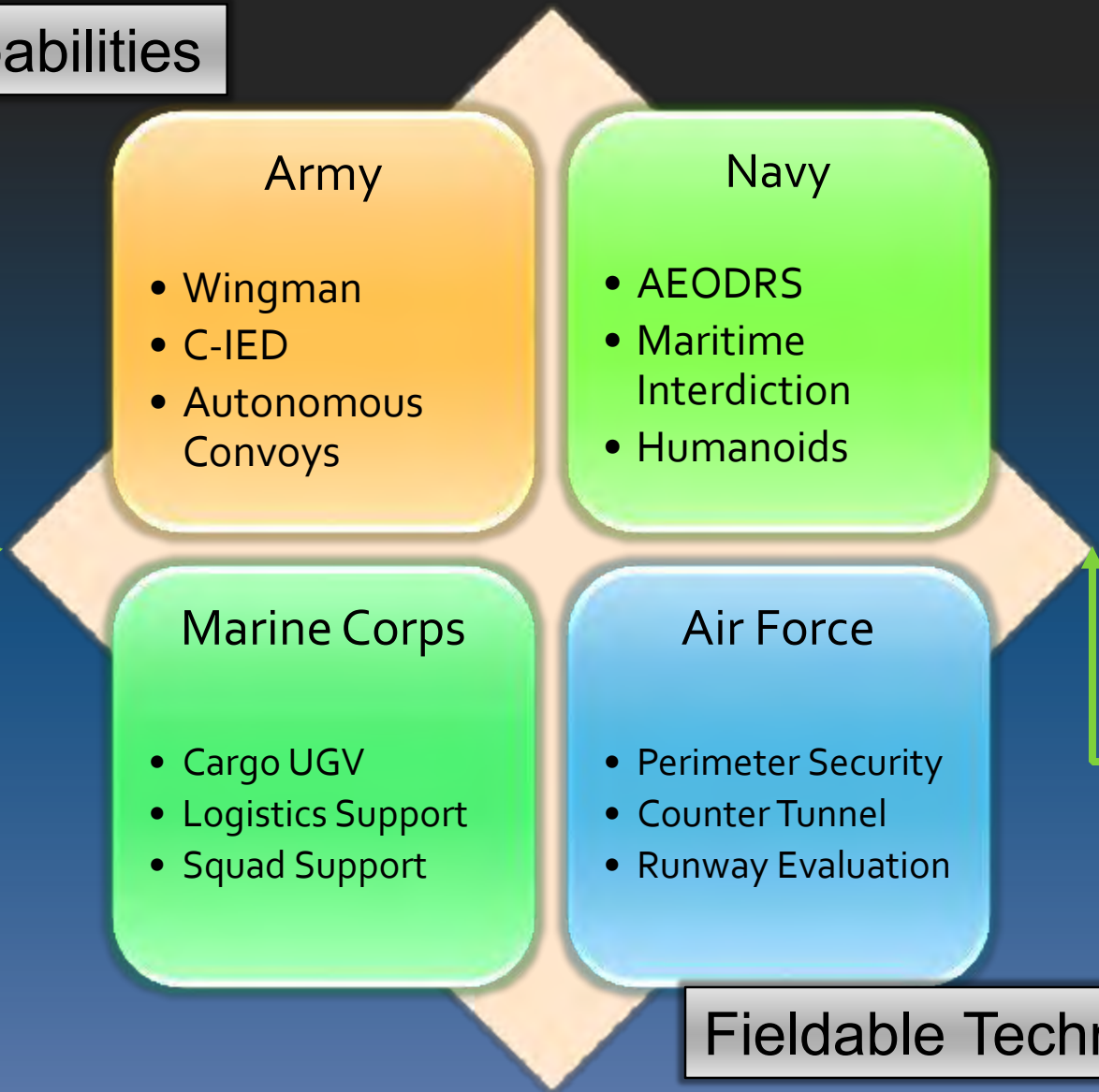
RTC Membership



178 Members
~39% are Non-Traditional

Requirements

Desired Capabilities



Fieldable Technologies

Requirements – Our Goal

- Right now, requirements under development call for doing the same things we normally do, only with unmanned systems
  - Counter-IED
  - Autonomous Convoy OPS
  - EOD missions
- Eventually, we hope to do more than just extend the reach/sight of our Warfighters
  - Robots as Teammates/Co-workers/Co-inhabitants

Acquisition

- Although few formal programs of record exist, the community is starting to address traditional acquisition impediments:
  - Testing
    - Developmental, Operational, Safety→TRUST
  - Reliability, Maintainability, Supportability
  - Match operational benefit with deliverable capability
    - Are the benefits worth the investment?
  - Appropriate strategies given optempo and rate of technology maturation

Opportunities for Future Scientists and Engineers

Intelligent Ground Vehicle Competition

- Challenges college student teams to develop an Intelligent Vehicle to navigate a complicated obstacle course – includes extensive list of mobility and design requirements
- All levels of undergraduate and graduate education
- Students solicit and interact with industrial sponsors who provide component hardware and advice

Military Academies

- Establish communications between service academy professors and service labs
  - Air Force Academy Senior Design Project modeled on AFRL Counter Tunnel Project
- Provide access to current service inventory platforms
  - RSJPO Robotics Pool provided robots for training & educational tools

Opportunities for Future Scientists and Engineers (Cont'd)

FIRST Robotics

- Comprised of over 90,000 volunteers
- Supported by a network of more than 3,500 corporations, educational and professional institutions, and individuals
- Programs include:
  - FIRST Robotics Competition for Grades 9-12 (ages 14-18)
  - FIRST Tech Challenge for Grades 9-12 (ages 14-18)
  - FIRST LEGO League for Grades 4-8 (ages 9-16; 9-14 in the U.S. and Canada)
  - Junior FIRST LEGO League for Grades K-3 (ages 6-9)
  - FIRST Place for ages 6 to adult
  - FIRST Scholarship Program

Robotics Innovations Competition and Conference

- Supported by the National Science Foundation
- Challenge university-level students to engineer robotic solutions to real-world problems
- Stimulate students to imagine new robotics applications and encourage them to develop their ideas into working prototypes

Student Ground Robotics Demonstration on the National Mall

- Held by AUVSI Foundation during National Robotics Week
- Demos of student-built ground robots on the National Mall, in front of the U.S. Capitol in Washington, DC

Agenda

- The State of Ground Robotics
- Discussing the Theme
- What's New with JGRE?

Saving Lives - Saving $
Are Robot Recruits the Answer?

- Yes!
- Well, probably…
- It depends…
- I don't know, can you prove it?

EOD Robots Save Lives

FY12 Robotics Cost Benefit Analysis

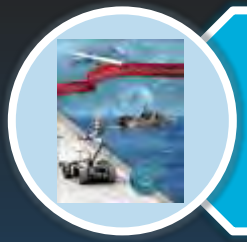
- The JGRE will be funding a CBA in FY12 to investigate the benefits of manned versus unmanned ground systems
- To date there has not been a formal Return on Investment of the life cycle costs of a manned system versus a unmanned alternative
- Potential missions being considered for the CBA include Convoy Operations, Logistics Support and Base Security
- Analysis will consider the full range of DOTMLPF* impacts.

*Doctrine, Organization, Training, Materiel, Leadership and education, Personnel, and Facilities

Agenda

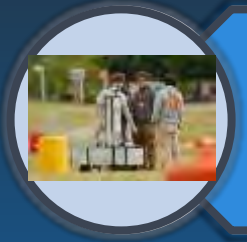
- The State of Ground Robotics
- Discussing the Theme
- What's New with JGRE?

JGRE Roles/Missions



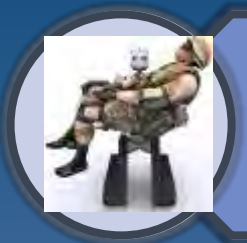
Synergy /Coordination

Congressional Direction



Outreach – Future Industrial Base

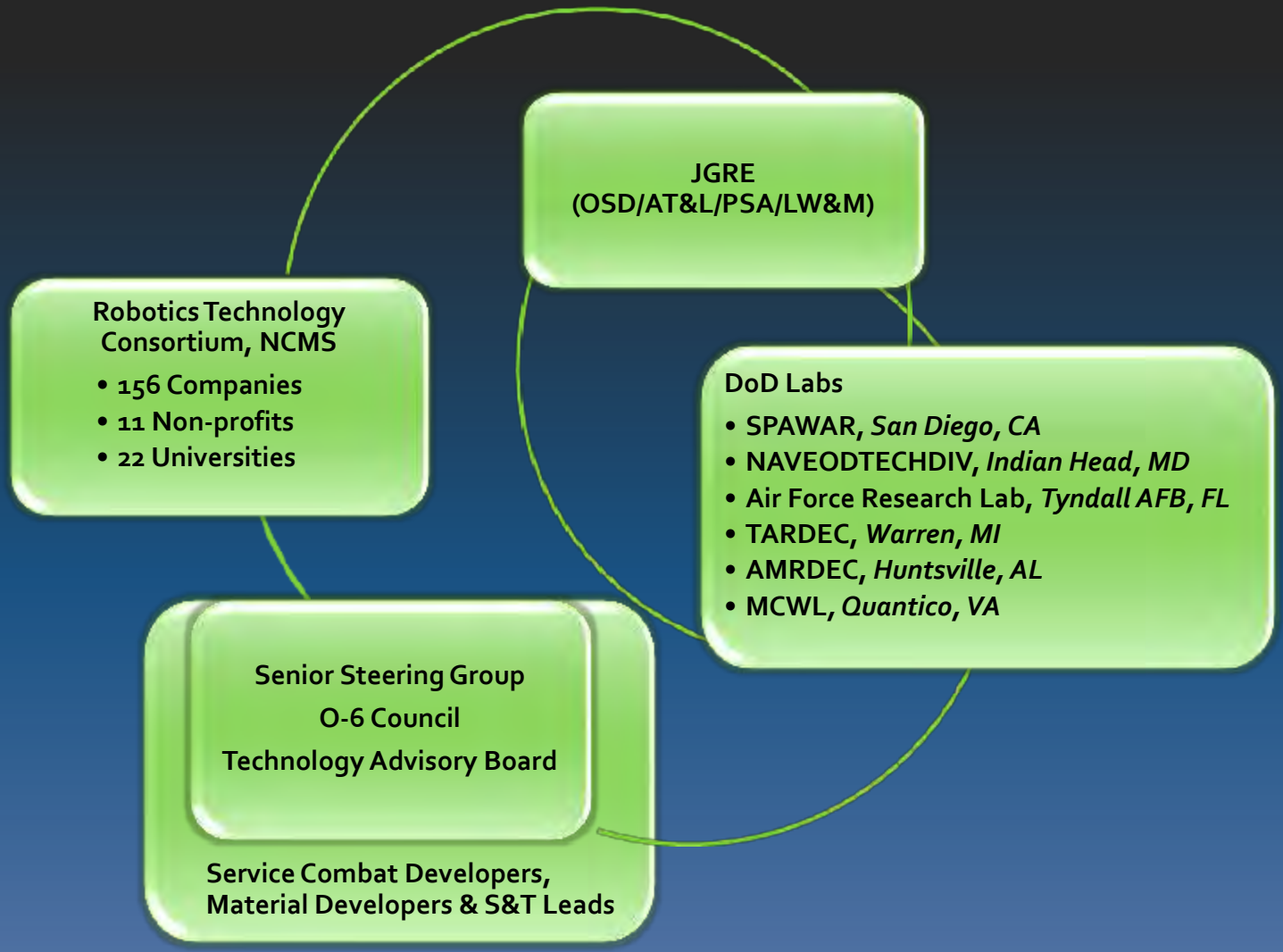
DoD Direction



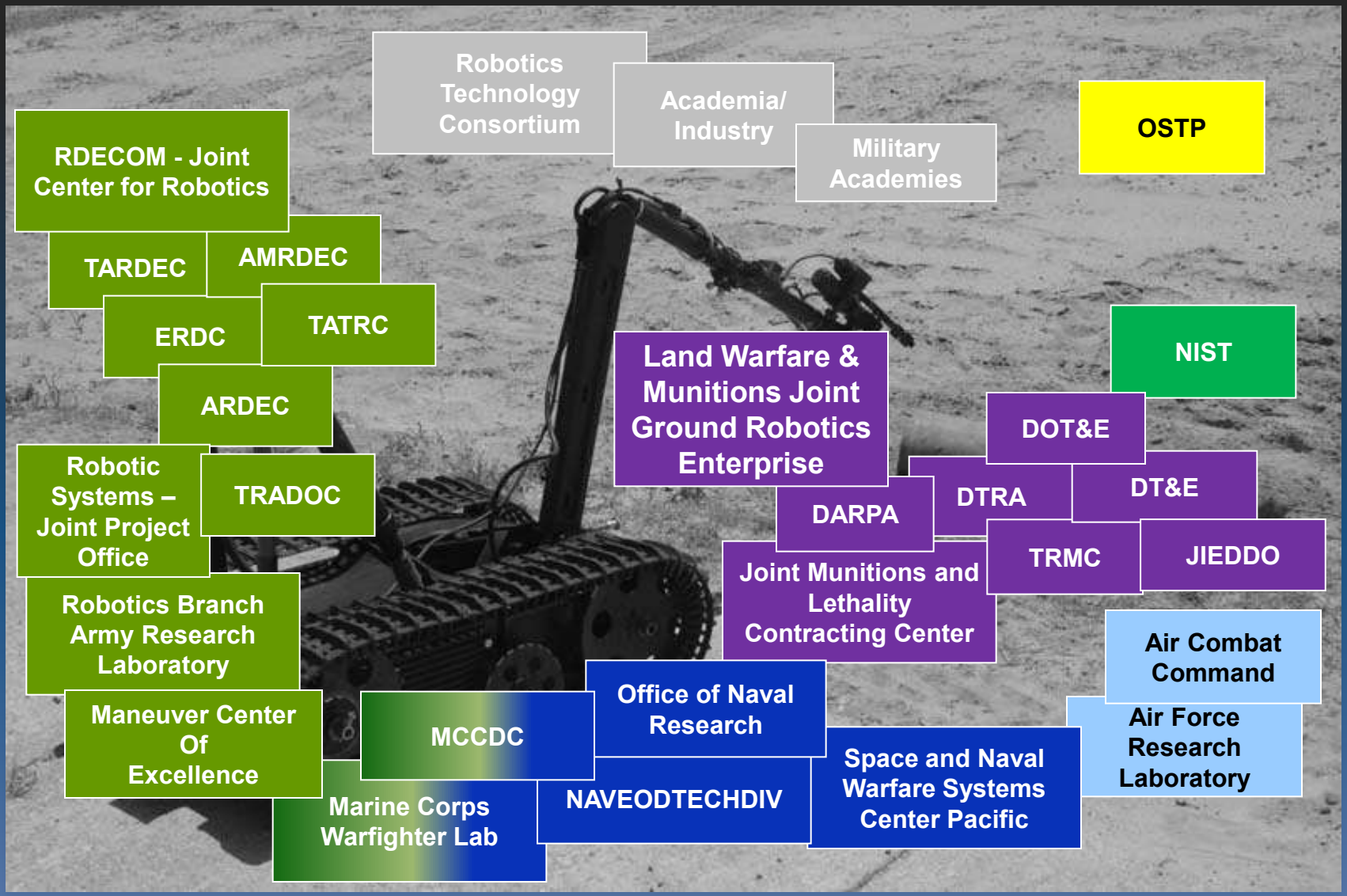
Technology Development & Funding Execution

JGRE Tech Selection Process

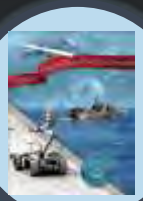
Enterprise Constituents



Enterprise Constituents

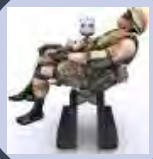


Enterprise Roles



Synergy/
Coordination

Outreach – Future Industrial Base



Technology Development & Funding Execution

Robotic Range Clearance Competition (R2C2)

- Goal
  - Advance the state of the art in robotics thru range clearance technologies
  - $2 Million in cash prizes
  - G3/5/7 releasing an IDIQ
- Why Range Clearance?
  - Currently there are millions of acres encumbered with spent training rounds and munitions debris
  - The competition will help provide a safer, more timely, and more cost effective way to return the land to productive use

Why Compete?

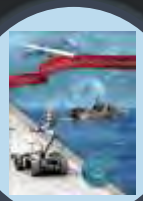
- OSD is offering prize money for the system that is most advanced and scores the highest
- Army Corps of Engineers in conjunction with the Army G3/5/7 will be releasing an IDIQ contract
  - Procure Services for Robotic Range Clearance
  - Participation in the competition will give competitors an opportunity to show the government success of their systems
  - Data collected for the competition can be used as test data to demonstrate capabilities for the IDIQ

R2C2 Summary

- DoD is looking for the Robotics Range Clearance Competition to:
  - Advance the state of the art in robotics range clearance technologies
  - Foster opportunity for COTS procurement for Robotic Range Clearance
  - Provide the best balance of efficiency and innovation in robotic technology development

8-19 August 2011 – Final Competition

Enterprise Roles

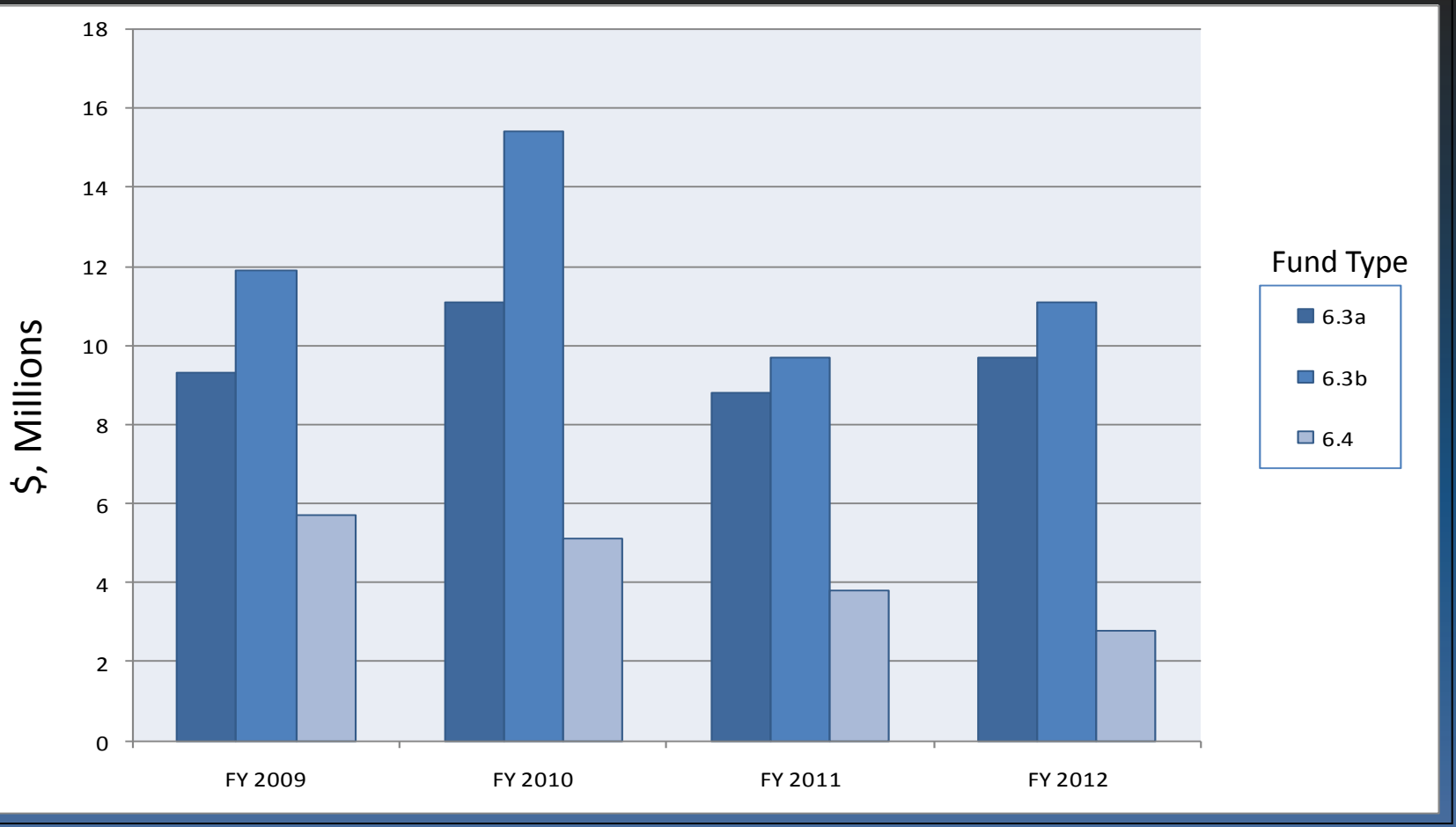


Synergy/
Coordination

Outreach – Future Industrial Base

Technology Development & Funding Execution

JGRE Funding Trends



Technical Challenges

Robots have limited ability to:

- Perceive and understand situations under all conditions
- Predict behavior of teammates or aggressors
- Collaborate with humans and other robots
- Learn tasks and adapt to new situations
- Move at near human speeds over any terrain
- Communicate effectively with other team members
- Lift, maneuver, and interact with physical objects

Some Things to Consider…

Ground Robotics are still newcomers to the fight, e.g. a technology leap/innovation.

Accepted theory suggests Technology Innovation will experience an increased rate of adoption if*:

- **It can be tried on a limited basis - "Trialability"**
- **The innovation offers observable results - Observability**
- **It offers an advantage over the status quo - Relative Advantage**
- **It is not overly complex to employ - Complexity**
- **It is compatible with existing practices and values - Compatibility**

* Theory of Perceived Attributes (Rogers, E.M., Diffusion of Innovations 4th Ed., New York: The Free Press, 1995)

Questions?

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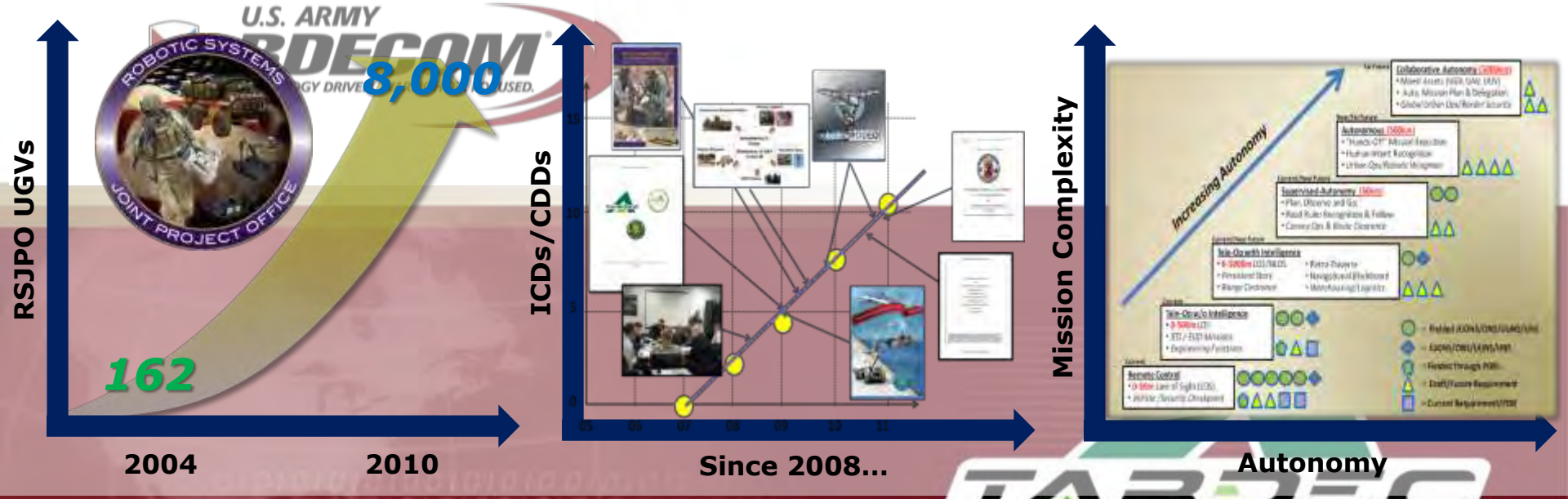
703-693-9414

Chief Roboticist Panel

Ground Robotics Capability Conference & Exhibition

Dr. Jim Overholt
Senior Research Scientist in Robotics
U.S. Army RDECOM-TARDEC



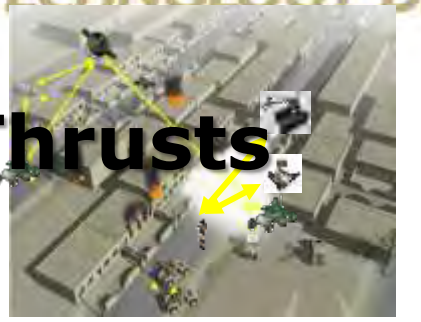
U.S. ARMY RDECOM

TARDEC

Increasing demands and operational flexibility
Require technology investments in key areas

TECHNOLOGY DRIVEN WARFIGH

Strategic Thrusts



Ongoing Robotics Efforts
How the Army will keep it's Technology Edge

MAST CTA
Basic Research for Micro-systems
BAE, JPL, Michigan, Penn, Maryland, GA Tech, UC Berkeley, MIT

- *Autonomous operation of a collaborative ensemble of multi-functional, mobile micro-systems*
- *Micro-mechanics*
- *Micro-electronics*
- *Processing for autonomy*
- *Integration of multi-functional component technologies*


Near-term Quad-rotor

Robotics CTA
Fundamental Robotics Research
GDRS ,CMU , UPENN, Qinetiq , UCF, Boston Dynamics, FAMU

- *Fundamental technology to enable teaming of "intelligent "unmanned systems with soldiers*
- *Perception*
- *Planning, learning, & adaptation to dynamic, unknown environments*
- *Human-robot interaction*
- *Dexterous manipulation & unique mobility*


CAMS JCTD vehicle

MAGIC
International Robotics Challenge
U of MI, U of PA, Robotics Research

- *Harvest "Best-in-class" technology for teaming of autonomous SUGVs*
- *Many robots/few operators*
- *Autonomous mobility*
- *Planning for dynamic environments*
- *Minimize required soldier interaction*
- *Tactical behaviors*
- *Heterogeneous teaming*


Team RASR's modified TALONs

RDP's
Research & Demonstration Projects Conducted by RDECOM & other Army Organizations

- *Focused Research and Advanced Development programs directed at maturation and demonstration of new technical capabilities*
- *Safe Operations of Unmanned Systems in Complex Environments (SOURCE)*
- *Improved Mobility and Operational Performance through Autonomous Technologies (IMOPAT)*


TARDEC APD Testbed Platform

Robotics Rodeo
Industry S&T Market-Survey
iRobot, Oshkosh, John Deeere

- *Open solicitation for developers to bring systems for assessment by both soldiers and technologists*
- *Structured assessments in relevant environments and exposition of broad swath of available technology*
- *Opportunity to include new & novel technology into Army Acquisition*


GUSS vehicle

'New' Partners

Automotive Safety Sensors

Automotive Industry

Wireless V-to-X communications

Automatic Platooning Systems

New Sensor Designs

Computer Industry

High Performance GPUs

New Players in Autonomy

The Innovation Circle

Military

Commercial

Maker

Discussion and Way Ahead

Robotics are *enablers* and catching on but, mainly as *force multipliers* – Not yet replacing *force structure*

Some Challenges:

Cultural

- An unwillingness to reduce force structure.
- Trust and confidence issues related to autonomous behaviors (safety)
- Appreciation of the potential return on a robotic investment.

Moral

- Responsibilities associated with the Unmanned application of force

Social

- The incurious nature (lack of curiosity in a machine).
- Lack of comfort for people to operate in close proximity to machines.

- Move beyond ONS/JUONS capability gaps
- Develop a Robotic Environment (Test Bed or Base Ops)
- Leverage modeling and simulation for comprehensive DOTMLPF impact

1) Determine return on investment for tasks robotics could perform (like robotic convoying)
2) Confirm that at various places along Bloom's taxonomy* or some combination of dull, dirty, or dangerous tasks, we can replace humans.
3) Determine personnel life-cycle cost savings
4) Expose the user and the military community to semi-autonomous robotics through test bed, base and installations operations

remembering-understanding-applying-analyzing-evaluating-creating

Adapting for Unmanned Systems

LTG Michael A. Vane

Deputy Commanding General, Futures, and
Director, Army Capabilities Integration Center
US Army Training and Doctrine Command

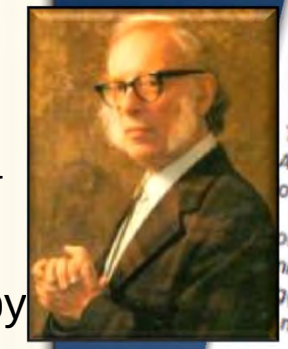
23 Mar 11

Isaac Asimov's "Three Laws of Robotics"

A robot may not injure a human being or, through inaction, allow a human being to come to harm.

A robot must obey orders given it by human beings except where such orders would conflict with the First Law.

A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.



COSMIC LOG

KILLER ROBOTS ... FRIEND OR FOE?

Posted: Tuesday, February 26, 2008 7:15 PM by Alan Boyle

Thousands of robots are **already on the battlefield** in Iraq and Afghanistan, but what happens when you hand the robot a gun and turn it loose?

Some researchers fear that giving military robots autonomy as well as ammo is the first step toward a "Terminator"-style nightmare, while others suggest that in some scenarios, weapon-wielding robots could someday do more humanely than humans.

The pros and cons of killer robots are taking center stage Wednesday in London, at what's considered the world's oldest military think tank, the **Royal United Services Institute.**

On one side of the issue is Ronald Arkin, a robotics researcher at Georgia Tech who is working on a Pentagon-funded project to build a sense of ethics into battlefield robots - "an artificial conscience, if you will," he told me.

"The basic rule is to try to engineer a system that will comply as best it can, given the information that it has, with the laws of war," Arkin explained. "And it's my belief that eventually we can do better than humans in this regard."

On the other side is Noel Sharkey, a robotics expert at Britain's University of Sheffield who served as chief judge for the long-running TV show **"Robot Wars."**

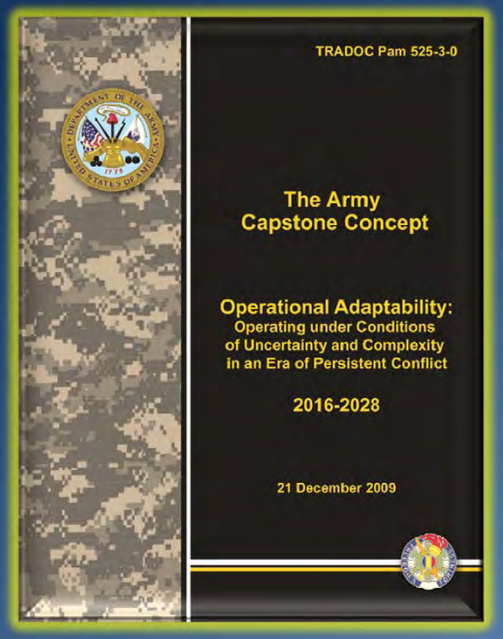
Nowadays, Sharkey is sounding the alarm about the prospect of real-life robot wars: He's calling


SINCE 189

“we must emphasize the integration of technology into capable formations commanded by innovative leaders who are comfortable operating under conditions of ambiguity and uncertainty.

To maximize the potential of technological developments, we must conscientiously evolve and adapt capabilities based on changes in threat capabilities and the operational environment”

GEN Martin Dempsey, CG TRADOC



“…robotics offer the potential to deploy appropriate combinations of manned and unmanned systems to perform an increasing range of tasks” ***pg 14 Promising Technologies***

“Fighting for information will require …the employment of appropriate combinations of manned and unmanned air and ground systems” ***pg 18 Supporting Ideas***

Guiding Principles …

- **Robotics *enable and replace the human***
- **Humans should *not have to accommodate***
- **Early user and technology developer collaboration**
- **Use "system of system" to measure effectiveness**
- ***Get more from force structure ; Cost / Benefit***

Potential Tasks and Feasibility…

Green – feasible *Amber – potentially feasible* *Red – Near-term infeasible*

Logistics

- Yard lift and short movement
- Cargo Packaging, warehouse opns
- Surface cargo transport and delivery
- Soldier sustainability: improved Solder strength and endurance

Security

- Perimeter security
- Remotely scan personnel/vehicles
- Casualty evacuation

Engineering

- Overcome obstacles, IEDs
- Mark, record, report obstacles
- Remove & clean contaminated areas

Medical

- Conduct pharmacy operations
- Perform tele-medicine / surgery
- Recover battlefield casualties
- Dispose of medical waste
- Perform battlefield first aid

Maintenance

- Perform diagnostic and PMCS
- Perform vehicle recovery
- Perform advanced manufacturing
- Perform tele-maintenance

- *Socio-moral implications*
- *Impact on available bandwidth and network spectrum management*
- *Leader training required to ensure effective integration of manned-unmanned systems*
- *Requires sufficient availability of systems to enable training at home station, power projection platforms, and CTCs*

The ethical and moral …

Thoughts on Autonomous Robots…

- ***Seamless integration*** **of robots into military & civilian society**
  - **Trust and confidence: transparency of action, cues to activity, tolerance to failure**
  - **Operating within society: adaptability to varying social cues and context**
- ***Autonomy is "conditional" …***
  - **Reliability**
  - **Task complexity**
  - **Variety of the operational environment**

Soldiers must be able to control autonomous systems to suit conditions as they change over time

Robotics Way-Ahead

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Robotics are *enablers* and catching on but, mainly as *force multipliers* – Not yet replacing *force structure*

- ***Move beyond ONS/JUONS capability gaps***
- ***Develop a Small Robotic Environment (Test Bed)***
- ***Leverage modeling and simulation for comprehensive DOTMLPF impact***
- ***Conduct Independent Robotics Efficiencies Study to:***

1) **Determine return on investment for tasks robotics could perform**
2) **Confirm that at various places along Bloom's taxonomy or some combination of dull, dirty, or dangerous tasks, we can replace humans.**
3) **Determine personnel life-cycle cost savings**
4) **Determine potential benefits associated with establishment of a test bed**

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Air Force Research Laboratory

Airbase Technologies Division

Tyndall Air Force Base, Florida

Force Protection Branch
Robotics Research Team
850-283-3725

Robotics Mission

AFRL
THE AIR FORCE RESEARCH LABORATORY
LEAD I DISCOVER I DEVELOP I DELIVER

Robotics Research Team Mission

The Air Force's Robotics Research Team conducts research and development of advanced robotic technologies and systems to protect, support , and augment the warfighter in the accomplishment of

Dull, Dirty, Dangerous, and Impossible Missions.

Robotic Technologies

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Research Areas

- Advanced Technologies Development
- Integrated Defense Technologies
- Robotic EOD Technologies
- Automated UXO Response Technologies
- Robotics for Airbase Operations and Support

Benefits to Warfighter

- Reduced manpower/time/cost for Range Clearance Ops
- Increased safety of deployed personnel
- Technical expertise
- Reduction of development time with existing systems and new capabilities

MACE

Rotary Wing UAV

Airborne ARTS In theater

I.V.A.N.

BOMBOT

Points of Contact

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